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EDITORIAL.

ITEMS AND NOVELTIES.

Stevens' Institute of Technology—*Continued* from Vol. 62, p. 146.—Various circumstances have caused a delay in the resumption of the description interrupted some months since, but in the meantime large additions have been made to the collections of all sorts, but as we have been apprised of these and other matters by the visit of the Mining Engineers to the Institution, our description will be more complete for the delay.

Our last moiety of this notice concluded the description of the workshops, furnaces, &c., of the basement floor. Ascending, then, by the stairway at the western wing of the building, we see, first of all, the entrance to the chemical laboratory opening towards the north.

Entering this room, we find it fitted with a number of stationary tables of the usual form for such work, each provided with its bottle-racks and sets of reagent bottles and gas pipes, as well as drawers and closets. Here are tables for forty students, though it is only intended that twenty should work at one time. At the further end of this room are large evaporating closets, heated by steam and supplied with numerous gas pipes, and at a convenient central point are located gas blast-lamps for igniting platinum crucibles, supply pipes

for oxygen and hydrogen gases from the reservoirs in the basement, filter pumps, sinks and hot air baths.

Adjacent to this laboratory, but not opening into it, is the balance room (No. 2 on plate), where are kept, free from any injurious gases, the delicate balances used in the analytical work.

Passing southward across the side hall we next enter the library (No. 3). This is a room some 45 by 60 feet, with lofty ceiling, supported by eight massive columns, against which abut from either side cases for books. These leaving the centre of the room clear, and also a passage way at either wall, divide the side spaces into ten alcoves. Six of these contain large glass cases, filled with pieces of apparatus and models, which do not find more convenient location in any of the apparatus rooms of special departments.

Thus, in one of these is the great Induction Coil, throwing sparks 21 inches long, which penetrate blocks of solid glass three inches thick, together with condensers, rotating apparatus, and countless Geissler's Tubes, as well as other instruments adapted for use with this powerful source electricity.

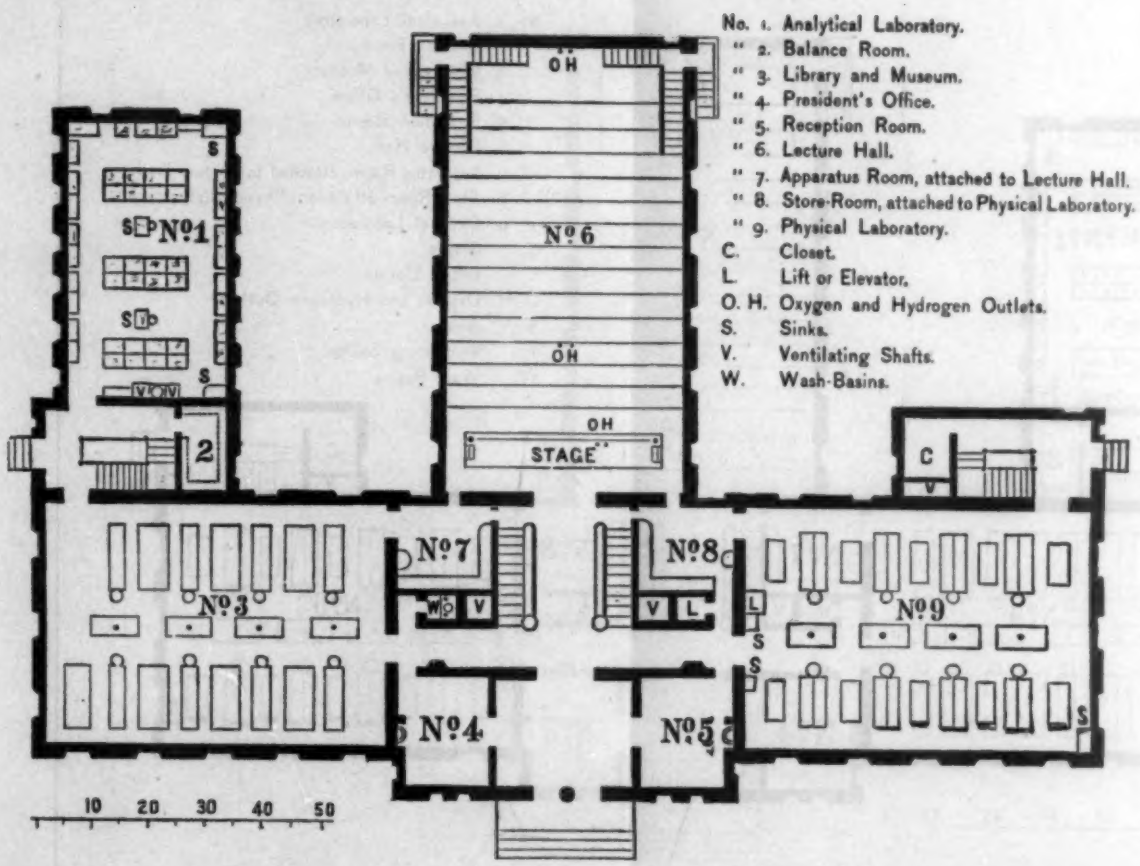
Another case contains the various lanterns used in the large lecture-room for public lectures, as well as the apparatus for illuminated water jets, the large air-pump, and other bulky apparatus employed chiefly in the same lecture hall.

Another case contains several pieces of apparatus for use in the physical laboratory, on the other side of the central hall, but too large to find permanent accommodation in its cases. Such, for example, is Regnault's apparatus for determining relation of temperature and tension of vapors, Dulong and Petit's apparatus for laws of cooling, the apparatus for measuring the elasticity of torsion, and Bourdon's beautiful apparatus for the illustration of vis viva, with its glass chamber, air gun, condensing pump and manometers.

Another case is filled with such large apparatus, for the illustration of the laws of sound, as Scott's Phonautograph, the card Siren of Seebeck, an organ of singing flames and tubes, Kœnig's apparatus of resonators and manometric flames, numerous sets of Chladni's plates and the like.

Another case contains a large electrical machine of the old plate form, a Holtz machine, together with batteries of Leyden jars and plates, and various other instruments for electrical demonstration, on the large scale, such as aurora tubes, electric eggs, Gassiot's Fountain, &c.

Stevens Institute of Technology.



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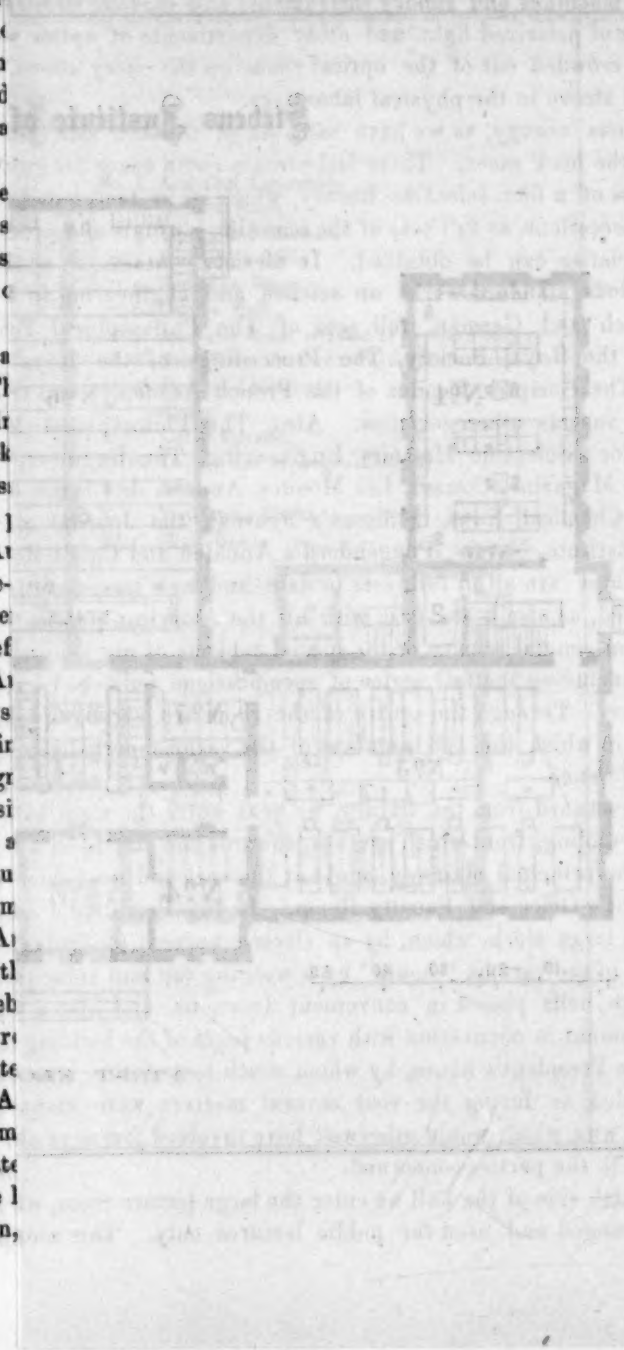


Finally, another case contains a number of bulky models of various important machines and sundry instruments and models, illustrating the subject of polarized light and other departments of optics which have been crowded out of the optical room on the story above, and the optical alcove in the physical laboratory.

These cases occupy, as we have said, six of the ten side alcoves cut off by the book cases. These last contain (with space for growth) the nucleus of a fine scientific library, which is, in fact, constantly receiving accessions, as full sets of the scientific journals and proceedings of societies can be obtained. It already contains, in addition to the various standard works on science and engineering in English, French and German, full sets of The Philosophical Transactions of the Royal Society, The Proceedings of the Royal Institution, The Comptes Rendus of the French Academy, and transactions of various other societies. Also, The Philosophical Magazine, Taylor's Scientific Memoirs, Engineering, The Engineer, The Mechanic's Magazine, Cosmos, Les Mondes, Annales de Chemie et de Physique, Chemical News, Silliman's Journal, the Journal of the Franklin Institute, Nature, Poggendorff's Annalen and Carl's Repertorium. These are all in full sets to date, and new issues are regularly received, as also is the case with all the American publications bearing upon general science or the special subjects of mechanical engineering, including the full series of specifications published by the Patent Office. Through the centre of the room are arranged tables with cases, in which the last numbers of the various periodicals are open for reference.

Passing eastward from the library, we next enter the main hall of the centre building, from which ascends, towards the north, in a double flight, the principal stairway, while at the east and west sides are the President's Office and Faculty Room. In the President's Office we notice a large clock, which, by an electric current, indicates the termination of the various "hours" by a warning tap and subsequent ring on large bells placed in convenient locations, and also a telegraph instrument in connection with various parts of the building and also with the President's house, by which much loss of time was evidently avoided, as during the visit several matters were managed through the wire which would otherwise have involved journeys about the building to the parties concerned.

On the north side of the hall we enter the large lecture-room, which has been arranged and used for public lectures only. This room is

55 feet wide by 80 feet deep, with a floor ascending in steps so as to secure a clear view of the stage from all parts.

Its open roof is painted in light shades, so that it lights up well in the evening. The stage slopes slightly towards the front, where there is a depression accommodating the sunken footlights and also serving as a gutter for water, which, in some experiments, such as those with illuminated fountains and the like, may be spilled upon the stage. A trap door at one side, when raised, gives to view supply pipes of oxygen, hydrogen, steam, illuminating gas, water and galvanic connections, as well as a water outlet; and another trap exposes a countershaft in connection with the main line in the basement, by which power also may be "laid on" when required.

At the rear of the stage is a white screen 16 feet square, and some 30 feet in front, on a very low table, so as to obstruct no line of view, is a lantern supplied with gases and electricity through its own trap. Connections for the same are found in various other parts of the room where they might become available.

Adjacent to the stage at either side are two small rooms, provided with fixtures for the preparation and arrangement of apparatus and experiments. (*To be continued.*)

A Canal between the Caspian and Black Seas.—A project is said to be on foot to connect these two great inland seas by a canal, the imperial government of Russia having the subject under consideration.

Geological evidences point very distinctly to the fact that both these vast bodies of water were formerly connected with what is now the Mediterranean, forming an arm of the sea with its northern terminus in the Polar Ocean, their separation having been effected by subsequent elevations of portions of the basin.

From very careful measurements recently made, it has been ascertained that the Caspian Sea is about 83 feet 6 inches lower than the Black Sea (older measurements placed the figures at 108 feet); and as the shores of the former are very low and flat, we have the curious circumstance that there are thousands of square miles of territory bordering upon them, including the sites of several very populous cities (Astrakhan amongst the number), which are really depressed below the level of the ocean. Those geologists who believe in the doctrine of cataclysms, might have ample scope for the exercise of the imagination by the simple supposition of the sudden subsidence of

the mountain barrier which confines the water of the black Sea within bounds. The proposed connection of the two seas, however, by means of a narrow channel, will, it is to be hoped, have nothing but a propitious effect in opening up inland communication and greatly increasing the trade of Russia. A straight channel is designed to connect the Manutch, a tributary of the Don, with the Kerma, a river which has its source in the Caucasus mountains. The length of the channel will be 680 verstes, or about 400 English miles; and the mountain range separating the two valleys will have to be pierced. It is estimated that the work will occupy 32,000 laborers about six years to bring it to completion. The cost is placed at 81,000,000 of roubles.

The St. Gothard Tunnel.—The plans projected for undertaking this colossal work, which will, if carried out, unite Italy and Germany by a commercial highway, seem to have found acceptance in the proper quarters. We are informed by foreign contemporaries that bids have been advertised both for the railway and tunnel, from which it may be assumed that the enterprise is fairly inaugurated. The latter will have a length of 9·2 miles, and will be entirely on a straight line. The summit rail level in the middle of the tunnel will be 3788 feet above sea level. The same section of tunnel as on the Mont Cenis is to be adopted, 26 ft. 2 in. wide, and 19 ft. 8½ in. high. From geological indications the following strata will have to be pierced, and in the order named:

	Yards.		Yards.
Granitic Gneiss,	2050	Gneiss and Mica Schist,	1545
Gneiss,	393	Hornblende and Schist,	1336
Schists (with Marble),	3050	Dolomite and Gypsum,	710
Granitic Gneiss,	4100		
Gneiss,	508	Total,	16192
Granitic Gneiss,	2500		

Contractors are invited to submit proposals with reference to the work, up to the 18th of next May, to the administration of the St. Gothard Railway.

The Draw Span of the Davenport Bridge.*—The draw span of the new bridge over the Mississippi at Davenport, which was turned for the first time a few days ago, deserves a passing notice, at least. It is the longest and heaviest in America, if not in the world, but so

* Iron Age, ix, No. 35.

perfect in its mechanical details that it can be opened and closed by two men. The draw span as it stands is a Whipple truss inverted; that is, its top chord is in tension and its bottom chord is in compression, which is exactly the reverse of the style of the fixed spans of the bridge. The whole strain of the draw truss is carried right to the centre from the ends, while in the fixed spans the strain is transmitted from the bottom of the posts up to the tie bars to the ends, throwing the top chord into compression.

The draw is, in exact figures, 306 ft. ¼ inch in length, and the posts are 46 in number. These, to be perpendicular, are connected by top and bottom chords, top and bottom struts, and diagonal lateral bracing.

The weight of the iron in the span, exclusive of the turn-table, is 871,784 pounds, or 426 tons.

The Thames Embankment.—The character and the inauguration of this important undertaking have already been described in this journal.

From a recent article in a contemporary* we are enabled to condense some information concerning the present state of the work and the prospects for its completion.

The embankment wall is of Portland cement concrete, faced with granite, the construction so far being similar to that adopted in the Albert and the eastern portion of the Victoria Embankments. The granite, however, instead of being smooth-faced, as in these two works, is drafted and scabbled-faced. The parapet and pedestals for lamp standards are of fine-dressed solid granite. The roadway to be formed at the back of the embankment will be 70 feet in width, and will be of macadam, with a substratum of concrete.

The work of construction is carried on by day and night, a small gas main, fitted at intervals with burners, being laid along the whole length of the staging. Considerable progress has been made since the work was commenced, last August, the granite work having in some places been carried up to the parapet top. Up to the present time more than 50,000 cubic feet of granite have been fixed, and about 12,000 yards of concrete work have been constructed. When completed the embankment will have absorbed about 200,000 cubic feet of granite, whilst in the backing there will be some 26,000 cubic

* Engineering, xiii, 325.

yards of concrete. The sewer will require some 3,000,000 bricks, besides a large quantity of concrete and numerous pipe connections. The progress at present making on the works is such as to warrant the assumption that the embankment will be completed about August, 1873.

The Westinghouse Brake.—This invention, which has been so extensively introduced in this country, being used upon no less than eighty-five railroads, has now found its way into England. The Caledonian and the London and Northwestern railroads are giving it a trial.

Estimating the Speed of Trains.—Several devices have been contrived to register the speed of trains, but none of sufficient simplicity to come into general use have yet been suggested.

Messrs. Samman and von Weber's construction, a German invention, consists of a disc driven by clock-work and a recording pencil. While the train is halting this describes a circle, but during the journey a crooked line is produced by the vibration.

In M. Cremer's apparatus, a strip of paper moves by clock-work. This paper is graduated and marked in minutes. A needle, with an up and down motion, which is in connection with an axle, pricks the paper. The distance of the holes serves as a guide in calculating the speed. On French railways a contrivance is met with, in principle not unlike the centrifugal governor, the coupling-box of which is in connection with and moves a pencil. In Shiff's apparatus, which is not unlike that of Cremer, the needle is moved by a battery, which renders its working more complicated and uncertain.

An Alloy to Unite Iron and Brass.—C. Mene* communicates the fact that an alloy, composed of 3 parts of tin, 39·5 copper and 7·5 parts of zinc, is very well adapted for joining brass or copper to iron and steel. The author suggests likewise the propriety of increasing the proportion of zinc in the mixture to 10 parts, since the heat of the smelting operation volatilizes enough of it to bring it down to the amount named.

A New Locality for Diaspore.—Mr. Trautwine informed the Editor of this Journal, that he has found transparent crystals of Dias-

* Revue Hebdom. de Chimie, &c., March 14th, 1872.

pore on the corundum of Franklin, Macon Co., North Carolina. Some of the crystals are colorless, and others of a very light pinkish tinge.

A Steam Jet for Exhausting Air, &c.—At a recent meeting of the Institution of Mechanical Engineers, at Birmingham, England, Mr. C. W. Siemens presented a paper upon an improved steam jet, capable of being effectively applied to a number of purposes in the arts.

The apparatus, which is recommended as the most satisfactory in avoiding eddies in the combined current of steam and air, and in utilizing most completely the initial momentum of the steam, consists in the employment of a very thin annular jet of steam in the form of a hollow cylindrical column discharged from an annular nozzle.

The air to be propelled by the steam jet is admitted through an exterior annular passage surrounding the steam jet, as well as through the centre of the hollow jet.

To avoid the formation of the eddies which have previously impaired the efficiency of this mechanical agent, it was found serviceable to contract the area of the air passages on approaching the jet, whereby the velocity of the two air currents is brought to a maximum. By the annular form of the jet the amount of surface of air exposed to the exhausting action is largely increased, and thus the maximum delivery of air is attained from a given amount of steam. The discharge enters an expanding delivery pipe, of considerable length, in which its momentum is gradually diminished.

This form of jet has been applied for exhausting one of the pneumatic dispatch tubes at the Central Telegraph Station, London, employed for conveying the carriers containing telegraphic dispatches from one station to another. A comparative trial of the jet and a good steam engine and exhausting pump proved that the expenditure of steam in the two cases was about the same for doing the same work, the advantage, however, being decidedly in favor of the jet, on account of its comparatively low first cost, simplicity of construction and economy of space.

It is proposed to apply the steam jet for exhausting the vacuum pans employed in sugar boiling, so as to dispense with the present expensive vacuum pumps and steam engine, and the condenser for condensing the vapor from the evaporating pan. It is also proposed to apply it to the lifting of water from moderate depths, by employing the jet to exhaust the air from a closed vessel, into which the

water rises under atmospheric pressure. The discharge from the jet is then admitted at the top of the vessel, and the water ejected through a delivery valve at bottom, the jet aiding in its expulsion.

In addition to those above named, the inventor mentioned numerous other mechanical processes in which the jet might be employed with good effect.

A Lecture Experiment.—It is well known that a light ball, as as of cork, is sustained for some time near the summit of a vertical jet of water, issuing from an orifice of such a nature that the steadiness of the jet is maintained.

The experiment becomes more striking when a vertical blast of air issuing from a large bellows is substituted for the jet of water, as in this case there is no apparent support for the ball, which comports itself in a very amusing manner.

When a strong blast cannot be obtained, if a slender wire, about four times the length of the diameter of the ball, be passed through its centre, so as to have one-fourth of its length projecting from one end, and one half from the other, the balancing is more readily obtained, as any considerable change in the relative positions of the centre of gravity and the point of support, is prevented by the movements of the rod. *Dept. Physics Central High School.*

A Simple Phonautograph.—By Prof. E. J. Houston.—Each of the many vibrations that have concurred in the production of a musical note can be recorded so as to be visible to a moderately large audience, by the use of no other apparatus than a piece of chalk and an ordinary blackboard.

The peculiarly shrill, disagreeable sound, often heard when a slate pencil or piece of chalk is drawn rapidly over a slate, is well known. It occurs when the contact between the pencil and the slate is not continuous. Each time the pencil touches the slate a slight tap is produced, and these taps, following each other rapidly, link themselves into a sound more or less musical. They may be legibly recorded as follows:

An ordinary chalk crayon is held loosely in the hand near one end, and inclined so that the acute angle made by the other end with the surface of a blackboard is about 30°. If now the crayon be pushed in the direction of the obtuse angle, it will be set into rapid vibrations, and, striking against the board at nearly equal intervals, will

produce a musical note. At each contact a legible mark is made on the board. By giving the chalk a uniform velocity, the pitch of the sound is kept quite constant, and the exact number of vibrations corresponding to any particular note, can be readily ascertained by counting the marks impressed on the board in a given time.

A very little practice will enable one to produce these effects quite readily. By altering the inclination and pressure, the pitch of the note can be varied at will, and the class or audience enabled to see the cause of the variations in notes of different pitch. In many cases, by a close inspection of the marks, it will be seen that each of them has been formed by two or more separate marks, one of which is generally more prominent than the others. This corresponds to the fundamental tone of the sound, the others to the overtones, and thus we have a visible proof of the cause of the difference in quality observable in certain notes of the same pitch. By considerable practice, the variations in the pitch of the notes can be obtained so readily that a tune may even be evoked from the board, which after the performance will contain a physical analysis of the individual notes.

The dots can be made to present quite an uniform appearance, and can therefore be profitably introduced in drawing the dotted lines in mathematical figures, or in off-hand sketches for lecture illustration.

—*Dept. Physics, Central High School.*

On the Flow of Water in Rivers and Canals.—By J. Farrand Henry, Ph. B.—The following lines, which were inadvertently omitted during the course of this article, our readers will please supply at proper place, namely, at the close of article on page 262, vol. lxii:

Before the commencement of the second season's observations the telegraphic meter was invented, and gave results which agreed well among themselves, but very different from the floats.

A series of comparisons between the floats and meter, at different depths, were made, to obtain a correction for the work of the first season, or the co-efficient of the double floats. These comparisons were taken in the St. Clair River, where it was over fifty feet deep, the meter being anchored opposite the middle of the base line, and as nearly as possible in the path of the floats.

The velocity of the current given by the floats and meter, at different depths, with the resultant velocity and direction of the wind parallel to the base line, are given in Table V.

Photo-Engraving on Metals.—A recent process for producing engraved surfaces in metal by photography is described as follows: A pure silver (or alloy) surface is first taken, and after finely polishing or frosting it is exposed to the action of iodine, and a film of iodide of silver thus obtained. The plate is then exposed to the action of the light, in the camera or under a photographic negative, until a faint image is obtained. It is then submitted to the action of an electrotype battery (copper solution), when a well-defined image of the object is obtained in copper (the copper only attaches itself to those portions of the plate which have been rendered conductors of electricity by the action of the light). The plate is next dried and etching solution poured over it, composed of sulphuric acid and nitrate of potash (or their equivalents). This immediately attacks the shadows, or exposed portions of the silver surface, while the copper parts from the electrotype bath are not affected. After etching to the required depth, the copper deposit may be removed by *aqua regia*, leaving a finely etched image on the silver plate. To engrave on steel, copper, etc., it is first necessary to coat the surfaces with pure silver, after which the process is substantially the same as that above described, with some modifications in the acids or combinations used, according to the nature of the metal employed.

The Oxygen Light.—In relation to the oxygen light of Tessie du Motay, of which mention was made in the last issue, it may be stated in addition that M. P. Thomas, acting under instructions from the Paris Society of Civil Engineers, has recently presented to this body a report upon the process. This report simply treats of technical advantages and disadvantages, leaving out of sight the economical question, which is somewhat to be regretted in view of the indistinct statement of the causes which have led to its removal from some of the streets of Paris where it had been introduced.

The conclusions arrived at are the following:

1. Theoretically, the combustion of oxygen does not increase the illuminating power of a given volume of gas.

2. Practically, however, it enables a burner to consume four times the quantity of gas that can be burned in air, without detriment to the utilization of the light which may be developed. In particular, it utilizes the entire luminous capacity of the gases, however rich, and in almost any quantity. Consequently it would be disadvantageous to employ it for ordinary street-lighting, on account of the limited

quantity of gas consumed by the burners, the only advantage gained being the beauty of the light, provided the gas is very rich. (Here, unquestionably, would come in the objection of expense from the complication of the apparatus).

But it is very advantageous, and the more so in direct proportion to the richness of the gases employed—for great centres of light (sun burners, &c.), where a large volume of gas is to be consumed without loss.

Separation of Soda and Potash.—In relation to the process of Schlösing for separating these substances by the formation of the perchlorate of potassa, which was briefly described in the preceding number of the *Journal*, it is proper to add that Prof. H. Kolbe has tested it, and has found that the perchlorate is somewhat soluble in 86 per ct. alcohol, and that therefore he does not recommend the use of the process.

Iron versus Steel.—In the able article, "On the Principles of Gun Construction," published in this Journal, the author calls attention to the method generally employed to estimate the tensile strength of steel and iron, namely, the adoption as standard units of the results given by the extreme proof of specimens having a section of about one square inch, or in some cases less, from which the strength of large masses is then obtained by theoretical formulæ—qualified by the introduction of a large factor of safety. In other words, after an elaborate calculation, it is found necessary, for no apparent reason, to throw away arbitrarily four-fifths of the result as erroneous, and keep only the other fifth as the amount of strain which the metal in mass can be relied upon to sustain. That a new theory is necessary to estimate the strength of materials would, from the foregoing, seem to be the case; for so great a discrepancy between the calculated and actual results as four-fifths of the total amount, seems to be altogether too great to ascribe to want of homogeneity, poor workmanship, &c. The facts point very strongly to the conclusion that many careful testing experiments are necessary with large masses of metal in order to detect the unknown cause of the remarkable variation between theoretical and actual estimates of strength. In this direction very little has been done; the only experiments at all thorough being those referred to by the author of the article above named, which were made by Col. James B. Eads, the able engineer of the St. Louis bridge. Below will be found a short statement of the results obtained

from some comparative tests with iron and steel shafts designed for use upon the bridge.

So loud, of late, have been the praises of steel over iron, and so general the confidence in it, that only the minor shafts of the great bridge were designed to be of iron; the remainder, embracing the more important parts were to be of steel. In order to be assured of the excellence of every portion of the structure the engineer in charge, not content with the results obtained from the straining of small sections, determined to subject every shaft supplied to a similar strain; and for this purpose constructed an enormous hydraulic testing machine. Thirty-two shafts, each nearly forty feet long and weighing nearly two tons, were furnished by Messrs. Macpherson, Willard & Co., the well-known iron forgers. These were subjected to a strain of about 300 tons without stretching—a strain so nearly approaching the resistance of sound iron that a slight flaw in any of them would have caused rupture; a fact which speaks well for the excellence of the work.

With the steel shafts, from which so much was expected, the result was very different. Many of them snapped under strains, in some cases even less than those which the iron ones stood perfectly, and so great became the distrust of them that the forge was ordered to proceed with more iron ones to take the place of steel, and have now furnished nearly a hundred without a single failure. These results also emphasize, if they do not inaugurate, a tendency in the engineering world to return from steel to iron when employed in large masses. We have long known all about steel in small sections, but till recently no large masses of steel could be produced, and this series of tests by Captain Eads is the first instance on record of attempts to ascertain whether the known laws of strength of small sections hold good in large masses of either wrought-iron or steel. A practical comparison of the two metals was made two years ago on the C. & A. R. R. boat "Red Jacket," with its two screws—the shafts being of equal size, one steel, one iron. The steel one twisted off in a week, while the two iron ones (one now replacing steel) both made here, have been running ever since. What the difficulty is with steel in the large mass is not clear, but the long list of failures of steel guns confirms the facts. Krupp, the great Prussian steel maker, has already abandoned the solid forged-steel gun. The matter is exciting considerable interest in the engineering fraternity and journals, and in practice, for large masses, there is a probable return for the present, to

the old-fashioned wrought-iron in vogue ever since the days of Tubal Cain.

The Centennial Exhibition.—The Commission having the inauguration of the great national exposition of 1876 in charge, has at length, after several meetings, advanced far enough to have presented to it a report of progress in arranging a system of classification to be followed on the occasion. The report was presented through Prof. William P. Blake, Chairman of the Committee on Classification, and it was ordered that the Committee be instructed to complete the system of the departments reported, a copy of the same to be then sent to each member of the commission, to be considered and acted upon at the next meeting. The contents of the report is briefly as follows:

We propose ten comprehensive divisions, to be named departments, as follows:

Department I.—Raw Materials—Products of the Soil, of the Mines and of the Sea, and their immediate derivations

Department II.—Materials the result of manufacturing processes, Chemical Compounds, Manufactures and Products.

Department III.—Textile and felted Fabrics, including Ready-made Clothing and Costumes, &c.

Department IV.—Furniture and Manufactures of general use.

Department V.—Tools, Implements, Machines and Processes.

Department VI.—Apparatus and Methods of Transportation.

Department VII.—Apparatus and Methods of the increase and diffusion of knowledge.

Department VIII.—Civil, Mining and Military Engineering, Public Works and Architecture.

Department IX.—Fine Arts—(Æsthetics).

Department X.—Objects illustrating the results of efforts for the improvement of the Moral and Physical Condition of Man.

We propose to subdivide each of these Departments into ten Groups, and each Group into ten Classes, thus giving abundance of latitude for the appropriate reference and classification of any object. It was one of the defects of the classification of 1867 that there were not enough classes. The arrangement we now propose not only remedies this difficulty, but it also gives us elasticity and an opportunity for expansion under every group and under every department, an advantage that only those who have had to deal with exhibitions can fully understand and appreciate. By assigning ten groups to each department we do not intend in all cases to specify and name every one of those groups at the outset. If we can properly put all that belongs in each Department into five or six or eight groups, we propose to do so, leaving the other numbers blank; so also of the classes. Each of the groups permit ten classes. In some cases the objects included by the groups can with propriety be placed in less than ten classes. But as the work progresses and new inventions are made, and new manufactures or processes arise, we may, under the plan suggested, institute a new class or a new group without changing the title or place of those already established. This brings us to the consideration of the system of notation.

The Departments will be numbered from I to X, and the Groups from 1 to 100, while the Classes will be numbered from 1 to 1,000. Thus the number of any Class will at once indicate the Group and the Department to which it belongs. This is a system similar to that upon which the houses are numbered in the city of Philadelphia, where the number of the house at once indicates its location with respect to the streets.

In illustration of the subdivision of Departments into Groups and Classes, we introduce the following tentative examples, premising that they are as yet preliminary and subject to such revision and changes as in the progress of our work we may find necessary.

Department I.—Group 1-10—Raw Materials—Products of the soil, of the mines and of the sea, and their immediate derivatives. Group 1—Minerals and Ores. Classes 1-10. Group 2—Metallurgical Products. Classes 11-20. Group 3—Cereals and Grasses—Wheat, corn, barley, oats, rye. Classes 21-30. Group 4—Plants, Flowers, &c. Classes 31-40. Group 5—Fruits, Root Crops, Seeds, &c. Classes 41-50. Group 6—Forest Products and Vegetable Fibres. Classes 51-60. 51. Logs, timber, plank, boards, lumber. 52. Shingles, pickets, shooks, hoops, &c., doors, windows, blinds, mouldings, worked lumber. 53. Barks, dye-woods, gums, resins, seeds, vegetable ivory 54. Fibrous Plants, fibres. Group. 7—Animals, Live Stock and Animal Products. Classes 61-70. Group 8—Fish and other Marine and Fresh Water Products. Classes 71-80. Group 9—Classes 81-90. We will take for another example one group of the third department.

Department III.—Textile and Felted Fabrics, including Ready-made Clothing and Costumes. Group 21—Woolen Yarns and Fabrics. Class 201, Card Wool Fabrics—Yarns, cloths, broadcloths, doeskins, fancy cassimeres. Class 202, Flannels—Plain, domets, opera and fancy. Class 203, Blankets, robes, shawls. Class 204, Worsted or Combed Wool Fabrics—Yarn, dress goods for women's wear, delaines, serges, poplins, merinoes. Class 205, Knit goods, hosiery and fancy. Class 206, Felts and Feltings other than Carpets. Class 207, Carpets—Brussels, Wiltons, tapestry, tapestry Brussels, Axminster, Venetian and feltings, ingrain, &c.

These two examples suffice to show how the ten departments are to be filled out, and the opportunity there is in each for expansion. It will be observed that no special place is assigned in this classification to objects of antiquity or to displays illustrating the progress of inventions. This omission is intentional. The proper place for such objects is in contiguity with objects for similar purposes, as, for example, in the group assigned to tools and implements we may place the stone axes and chisels of pre-historic times and of existing savage tribes. In the class assigned to boats we may place the canoes of ancient and modern date. But we may also, in following out the geographical element of our plan, give a section of the entire range of products and industry to objects of historical interest, especially to those showing the progress of industry and invention in the United States during the century. By so doing each object will find its appropriate place under the classification—the printing press of Franklin, for example, in the same range with those of Hoe, Adams and Bullock.

The cotton gin of Whitney, yet preserved, will stand side by side with those used to-day, and the early efforts to construct locomotives will be contrasted with the latest.

Special Exhibitions—It is not intended by this or by any classification to preclude any additional exhibitions of any special art or

industry, nor is it essential in all cases that objects included in any one class or group should be placed in exact juxtaposition with objects of the other classes. The nature of the objects themselves often prevents this. For example: flowers and trees cannot be grown in the building, nor can live stock be placed within the walls. In such cases, however, their appropriate position in the classification may be indicated by stuffed or preserved specimens, thus preventing any break in the practical realization of the system.

We believe that you will find the ten departments proposed sufficiently comprehensive, and that the fully elaborated classification under them will prove to be satisfactory. The detail can be filled in hereafter, but it would be well to adopt these grand divisions as the basis, recognizing at the same time the principle of geographical as well as systematic arrangement of the objects. Respectfully submitted,

Wm. R. Blake, John L. Campbell, Joshua Nye, Committee.

Editorial Correspondence.

Motions of Camphor on the Surface of Water.

Editor Jour. Franklin Institute.

Smithsonian Institution, Washington, March 13th, 1872.

Dear Sir:—In a letter just received from my friend, Mr. Tomlinson, of London, are the following remarks: "Will you allow me to call your attention to a slight error in the *Journal of the Franklin Institute* for 1870? In a short notice of a paper of mine, which appeared in the *Phil. Mag.*, for December, 1869, on the 'Motions of Camphor on the Surface of Water,' the Editor gives the credit of the new theory to Professor Plateau, of Ghent, whereas the theory, I examine, is by his son-in-law, my friend Prof. G. Van der Mensbrugghe, of the University of Ghent. Prof. Plateau reported on the theory to the Academy of Sciences at Paris, and this is probably the source of the error; for Plateau's name is in the text at the beginning of the article, and Van der M.'s name, with the title of his paper, is given in a note.

By making the correction as desired, you will obiige,

Yours, very truly, Joseph Henry,

Secretary Smithsonian Institution.

Civil and Mechanical Engineering.

THE IMPROVEMENT OF THE STEAM ENGINE AND THE EDUCATION OF ENGINEERS.

By Prof. R. H. Thurston.*

Having rapidly sketched the history of the Steam Engine and some of its most important applications, we may now take up the question: —*What is the problem, stated precisely and in its most general form, that engineers have here been attempting to solve?*

After stating the problem, we will examine the record with a view to determine what direction the path of improvement has taken hitherto, and, so far as we may judge the future by the past, by inference, to ascertain what appears to be the proper course for the present and for the immediate future.

Still further, we will inquire, what are the conditions, physical and intellectual, which best aid our progress in perfecting the steam engine.

This most important problem may be stated in its most general, yet definite, form as follows:

To construct a machine which shall, in the most perfect manner possible, convert the kinetic energy of heat into mechanical power, the heat being derived from the combustion of fuel, and steam being the receiver and conveyer of that heat.

The problem embodies two distinct and equally important inquiries.

The first:—*What are the scientific principles involved in the problem, as stated?*

The second:—*How shall a machine be constructed that shall most efficiently embody, and accord with, not only those scientific principles, but also all of those principles of engineering practice that so vitally affect the economical value of every machine?*

The one question is addressed to the man of science, the other to the engineer. They can only be satisfactorily answered, even so far as our knowledge at present permits, after studying with care the scientific principles involved in the theory of the steam engine under the best light that science can afford us, and by a careful study of the

* A paper read before the Polytechnic Association of the American Institute, being the concluding portion of a lecture addressed to mechanics and engineers at the Stevens Institute of Technology, February, 1872.

various steps of improvement that have taken place and of accompanying variations of structure, analyzing the effect of each change, and tracing the reasons therefor.

The theory of the steam engine is too important and too extensive a subject to be treated here in even the most concise possible manner.

I can only attempt a plain statement of the course which seems to be pointed out by science as the proper one to pursue in the endeavor to increase the economical efficiency of steam engines.

The teachings of science indicate that *success in economically deriving mechanical power from the energy of heat motion will, in all cases, be the greater as we work between more widely separated limits of temperature, and as we more perfectly provide against losses by dissipation of heat in the directions in which it is unavailable for the production of power.*

Scientific research has proved that, in all known varieties of heat engine, a large loss of effect is unavoidable from the fact that we cannot reduce the lower limit of temperature, in working, below a point which is far above the absolute zero of temperature; far above that point at which bodies have no heat motion; the point corresponding to the mean temperature of the surface of the earth is the lower limit.

The higher we carry the temperature of the steam when it enters the steam cylinder, and the lower that at which it arrives before the exhaust occurs, the greater, science tells us, will be our success, provided we at the same time avoid waste of heat and power.

Now, looking back over the history of the steam engine, let us rapidly note the prominent improvements and the most striking changes of form, and thus endeavor to obtain some idea of the general direction in which we are to look for further advance.

Beginning with the machine of Porta, at which point we may first take up an unbroken thread, it will be remembered that we there found a single vessel performing the functions of all the parts of a modern pumping engine; it was, at once, boiler, steam cylinder, and condenser, as well as both a lifting and a forcing pump.

The Marquis of Worcester divided the engine into two parts, using a separate boiler.

Savery duplicated that part of the engine of Worcester which performed the several parts of pump, steam cylinder and condenser, and added the use of water to effect rapid condensation.

Newcomen and Cowley next separated the pump from the steam

engine proper, and in their engine, as in Savery's, we noticed the use of surface condensation first and subsequently that of the jet, thrown into the midst of the steam to be condensed.

Watt finally effected the crowning improvements, and completed the movement of "differentiation" by separating the condenser from the steam cylinder. Here this movement ceased, the several important processes of the steam engine now being conducted, each in a separate vessel. The boiler furnished the steam, the cylinder derived from it mechanical power, and it was finally condensed in a separate vessel, while the power which had been obtained from it in the steam cylinder was transmitted through still other parts, to the pumps, or wherever work was to be done.

Watt also took the initiative in another direction. He continually increased the efficiency of the machine by improving the proportions of its parts and the character of its workmanship, thus making it possible to render available many of those improvements in detail, upon which effectiveness is so greatly dependent and which are only useful when made by a skilful workman.

Watt and his contemporaries also commenced that movement toward higher pressure of steam and greater expansion, which has been the most striking feature noticed in the progress of steam engineering since his time.

Newcomen used steam of barely more than atmospheric pressure, and raised 105,000 pounds of water one foot high with a pound of coal consumed. Smeaton raised the pressure somewhat and increased the duty considerably; Watt started with a duty double that of Newcomen, and raised it to 320,000 foot-pounds per pound of coal, with steam at ten pounds pressure.

To-day, Cornish engines of the same general plan as those of Watt, but worked with forty to sixty pounds of steam and expanding three or four times, do a duty probably averaging, with the better class of engines, 600,000 foot-pounds per pound of coal. The compound pumping engine runs the figure up to about 1,000,000.

The increase in steam pressure and in expansion since Watt's time, have been accompanied by a very great improvement in workmanship; a consequence, very largely, of the rapid increase in perfection, and in the wide range of adaptation of machine tools, by higher skill and intelligence in designing engines and boilers, by increased piston speed, greater care in obtaining dry steam, and in keeping it dry, until thrown out of the cylinder, either by steam jacketting or by

superheating, or both combined; and it has further been accompanied by greater attention to the important matter of providing carefully against losses by radiation and conduction of heat.

The use, finally, of the compound or double-cylinder engine for the purpose of saving some of the heat usually lost in consequence of condensation from great expansion, has already been alluded to when treating of the marine engine.

It is evident that, although there is a limit, tolerably well defined in the scale of temperature, below which we cannot expect to pass, a degree gained in approaching this lower limit is more remunerative than a degree gained, in the range of temperature, available by increased temperatures.*

Hence, the attempt made by the French inventor, Dr. Trembly, twenty-five years ago, and by other inventors since, to utilize a larger proportion of heat by approaching more closely the lower limit, was in accordance with known scientific principles. The form of engine here referred to is known among engineers as the Binary Vapor Engine. In it the heat of the water from the condenser of the steam engine is made to evaporate some very volatile liquid, as ether or carbon-di-sulphide, which, in turn, by the expansion of its vapor, develops additional mechanical power. Mechanical difficulties have hitherto prevented the success of this form of engine, but it cannot be pronounced unlikely that coming inventors may make the system commercially valuable.

We may now summarize the result of our examination of the growth of the steam engine thus:

First. The process of improvement has been one, primarily, of differentiation;† the number of parts has been continually increased; while the work of each part has been simplified, a separate organ being appropriated to each process in the cycle of operations.

* The fact here referred to is easily seen, if it is supposed that an engine is supplied with steam at a temperature of four hundred degrees above absolute zero, and works it, without waste, down to a temperature of two hundred degrees. Suppose one inventor to adapt the engine to the use of steam of a range from five hundred down to two hundred degrees, while another works his engine, with equally effective provision against losses, between the limits of four hundred and one hundred degrees—an equal range with a lower mean. The first case gives an efficiency of one half, the second three fifths, and the third three fourths, the latter giving the highest effect.

† This term, though perhaps not familiar to engineers, expresses the idea perfectly.

Secondly. A kind of secondary process of differentiation has, to some extent, followed the completion of the primary one, in which secondary process one operation is conducted partly in one and partly in another portion of the machine. This is illustrated by the two cylinders of the compound engine and by the duplication noticed in the Binary Engine.

Thirdly. The direction of improvement has been marked by a continual increase of steam pressure, greater expansion, provision for obtaining dry steam, high piston speed, careful protection against loss of heat by conduction or radiation, and, in marine engines, by surface condensation.

The direction which improvement seems now to be taking, and the proper direction, as indicated by an examination of the principles of science, as well as by our review of the steps already taken, would seem to be:

En resumé—working between the widest attainable limits of temperature.—Steam must enter the machine at the highest possible temperature, must be protected from waste and must retain, at the moment before exhaust, the least possible amount of heat. He whose inventive genius or mechanical skill contributes to effect either the use of higher steam with safety and without waste, or the reduction of the temperature of discharge, confers a boon upon mankind.

In detail: *In the engine*, the tendency is, and may probably be expected to continue, in the near future at least, toward higher steam pressure, greater expansion in more than one cylinder, steam jacketting, superheating, a careful use of non-conducting protectors against waste, and the adoption of higher piston speeds.

In the boiler, more complete combustion without excess of air passing through the furnace, and more thorough absorption of heat from the furnace gases.

The latter, I am inclined to suppose, will be ultimately effected by the use of a mechanically produced draught, in place of the far more wasteful method of obtaining it by the expenditure of heat in the chimney.

In construction we may anticipate the use of better materials and more careful workmanship, especially in the boiler, and much improvement in forms and proportions of detail.

In management, there is a wide field for improvement, which improvement we may feel assured will rapidly take place, as it has now become well understood that great care, skill and intelligence are im-

portant essentials to the economical management of the steam engine, and that they repay, liberally, all of the expense in time and money that are requisite to secure them.

In attempting improvements, in the directions that I have indicated, it would be the height of folly to assume that we have reached a limit in any one of them, or even that we have approached a limit.

If further progress seems checked by inadequate returns for efforts made, in any case, to advance beyond present practice, it becomes the duty of the engineer to detect the case of such hindrance, and, having found it, to remove it.

A few years ago, the movement toward the expansive working of high steam was checked by experiments, seeming to prove positive disadvantage to follow advance beyond a certain point.

A careful revisal of results, however, showed that this was true only with engines built, as was then common, in utter disregard of all the principles involved in such a use of steam, and of the precautions necessary to be taken to insure the gain, which science taught us, should follow.

The hindrances are mechanical, and it is for the engineer to remove them.

We have seen that the most important problem offered the engineer for solution is a double one, and that it requires the aid of both the scientist and the mechanist in its solution.

But it is sufficiently evident that, before the engineer can determine what form of machine will best yield to him the control of these forces of nature, he must have sufficient knowledge of science to be able to understand what scientific principles are to be rendered available, and what phenomena of nature are operating in the production of the power which he is to seize upon and usefully to apply. Otherwise he will grope in the dark, and will only learn, by the bitter experience of costly failures, to make slow progress toward perfection.

We have seen that the greatest improvements effected in the steam engine were due to the united engineering skill and experience and to the scientific attainments of James Watt.

We saw that his improvements followed a long course of intelligent and scientific research, and that directed by the results of this investigation, the engineering talent and the mechanical knowledge of the great inventor, accomplished more in a single life-time than had been previously accomplished in the whole period embraced in the history of civilization.

This great example confirms what we should infer from the nature of the problem itself, that *he who would accomplish most, in the profession of the mechanical engineer, must best combine scientific attainments, especially experimental knowledge, with mechanical tastes and ability and engineering experience.*

As one of our oldest engineers* tells him, he must "cultivate a knowledge of physical laws, without which eminence in the profession can never be securely attained."

He must become familiar, not only with science and the arts, but he must teach himself to make the one assist the other; he must learn just how to make use of scientific principles in planning his work, and how to do his work most thoroughly, efficiently and economically when he has determined his general design. He must be able to determine how far standard designs are in accordance with correct principles, to detect their defects and to provide a remedy correct in principle and mechanically efficient.

Science and Art must always work hand in hand.

But how is the rising generation of engineers to acquire this proficiency in both branches of knowledge? How are they to be made mentally and manually accomplished; how fitted for the great work which is before them?

The time has gone by when, in any art, the ignorant and merely dexterous workman can compete with even a less skilful shopmate, in the race for preferment, where the latter possesses and uses brains as well as hands, and knows how to make the one direct and aid the other. We, to-day, find him occupying a decided vantage ground who is, at the same time, familiar with the schools and at home in the workshop.

For whatever department in the arts a youth may be designed, he must, to insure success in the future, be taught, not "in school *or* the workshop," the alternative formerly offered him, but in the school *and* the workshop.

Here then rises the necessity of "Technical and Industrial Schools," in which, if properly conducted, knowledge is imparted so as not only to train the mind to habits of thought and study, to give it capacity for logical deduction, but in such a manner as shall, at the same time, make the student familiar with the principles of the art which he is to practice, and prepare him to learn the lessons taught in the workshop and the manufactory, rapidly and well.

* Charles Haswell.

It is the tardy recognition of this great want, this vital necessity, that has placed a great nation, which has been far in advance of all others in manufactures and the useful arts, in a position, relatively to her neighbors, that is causing the greatest uneasiness in the minds of the more intelligent of her people and of her statesmen.

They see nations, who were formerly far behind, now rapidly overtaking her, if not already taking the lead, in consequence of the earlier adoption of a system of technical education for their people.

Two hundred years ago, Edward Somerset, the second Marquis of Worcester, the inventor, with whose achievements you are familiar, informed his fellow-countrymen of the growing necessity for such a system of education for the people, and urged the establishment of technical schools.

For this he deserves higher honor than for anything that he did for the steam engine.

But the system first took a definite form upon the continent of Europe, and for more than a quarter of a century it has grown with the growth and strengthened with the strength of the western European nations, until it has, to-day, become a most important element of their national power.

In our own country this great need has long been recognized, but the policy of our government does not permit it to institute systems of teaching, as has been done by those of Europe, and it has remained, to a great degree, unprovided for.

Such education cannot be provided at the small cost that the average citizen can well afford to pay, and, even if that were possible, it is quite doubtful whether the vital necessity of such an education, to the people rather than the individual, and to the coming rather than to the present generation, would be sufficiently well understood to induce the payment of its actual cost, far below the real value, as it may be.

It becomes therefore the privilege and the duty of the wealthy among our citizens, to provide this great want of our country, and to aid, thus most effectively, in giving her that pre-eminence amongst the nations that every patriotic citizen aspires to see her attain.

I have referred to the services rendered by John Stevens and his sons in the introduction of the locomotive and the steamboat, but no single achievement of theirs, nor all combined, has conferred so great

* Lives of Bolton and Watt. By Samuel Smiles. London: John Murray. 1865—p. 13.

a benefit upon the country and upon the world, as did the bequest by which one of those sons, EDWIN A. STEVENS, founded a technical school, where the youth of the present and of succeeding generations are to be taught the principles upon which is based the profession which he and his father and brothers practiced with such splendid results.

In St. Paul's Cathedral is a Latin inscription which informs the visitor that no memorial is erected to its great architect, Sir Christopher Wren, but that his most appropriate monument is the great cathedral itself.

So it is here, we see no memorial erected to the founder of this first School of Mechanical Engineering, but "*si monumentum quaeris, circumspice.*"

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. RICHARDS, M. E.

(Continued from page 392, Vol. LXIII).

Motion in machinery is rotary and reciprocating, sometimes irregular, moving in parabolic or volute lines, but only in exceptional cases.

As everything in mechanics is supposed to conform to the laws of physical science, and when understood, to present nothing impracticable or difficult, it is rather anomalous to find certain inherent difficulties in the operating of machines, that we can have no hope of overcoming; yet reciprocating movements must be regarded in this light. Direct reciprocation of the parts of machines, at a uniform speed, throughout their range is almost impracticable, and is, indeed, seldom attempted. The accumulated momentum of a mass moving at a uniform speed, is as its weight multiplied into its velocity, and its impact can only be received by a resistance that is elastic and yielding. The reciprocating platens of printing presses serve as an illustration of this. They must be stopped at the extreme of their stroke by air cushions or springs, that act throughout two inches or more of their movement. Fortunately, however, necessity for reciprocating motion at a uniform speed throughout the stroke seldom exists. There is no doubt but what a movement of this kind would be advantageous for many purposes, where reciprocating motion is applied, but being impracticable, except at slow speeds, we manage very well with the crank. This simple device is one of the most important in the

whole range of mechanism, but few think, in watching the motion of a crank, or even in considering its principles, of the important place it fills among the agencies for transmitting force and motion. The crank converts rotary to reciprocating motion, or the reverse, and at the same time gives to the reciprocating parts the only movement which is practicable at high speeds; gradually accelerated from a still point at the centres, to a maximum on the "quarter," the movement is then gradually diminished to the other extreme or centre, leaving the weight in a state of rest, to be again set gradually in motion, in the opposite direction.

This explanation is, no doubt, in different terms from those that are used in a scientific way for defining crank movement, but it will be understood by the readers of the *Journal*, which serves the present purpose.

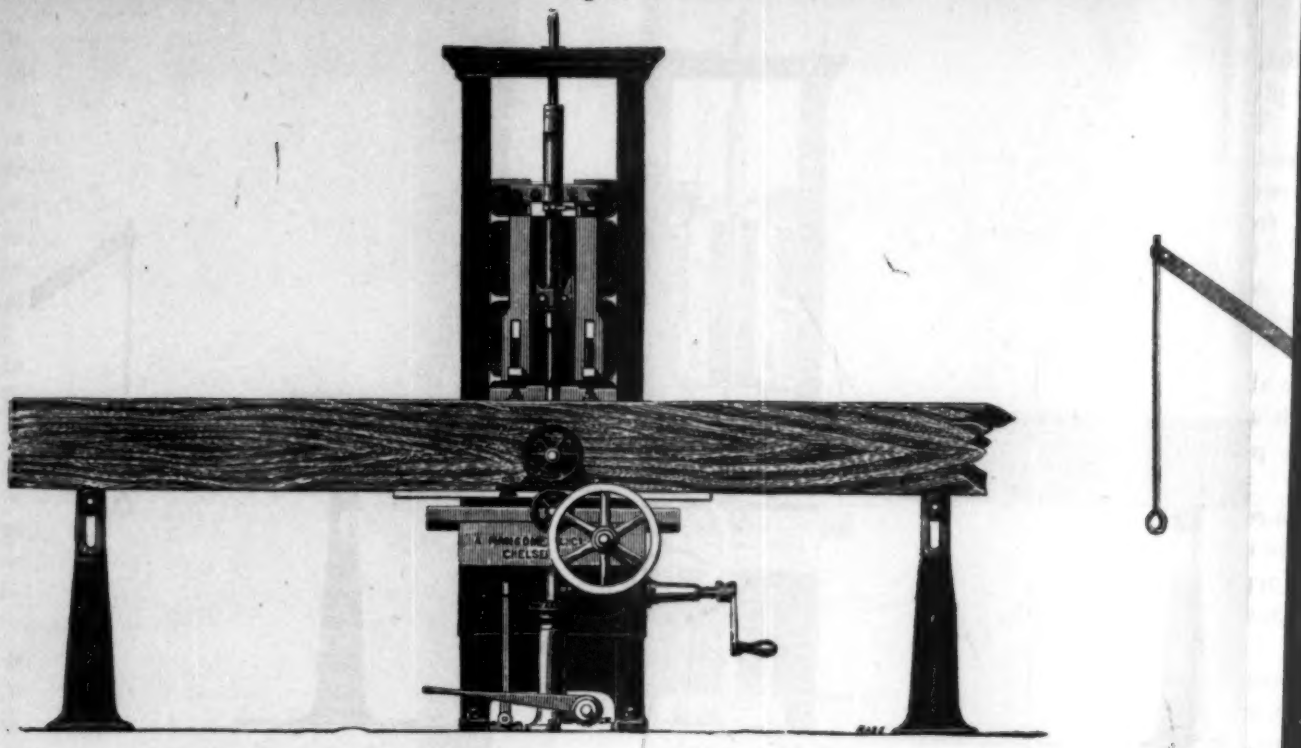
Besides the irregularity of movement by cranks, we have to contend with the almost equal difficulty of balancing. Reciprocating weights can only be balanced by a coincident movement in the opposite direction of equal weights, or their equivalent, measured by speed and weight.

It is common to apply counterbalances on the cranks of reciprocating machines, and properly, too, as it often serves a useful purpose, but, so far as amounting to a perfect balance to the reciprocating parts, or any part of them, it is of no avail. Reciprocating weight cannot be balanced with rotating weight; the motion and the effect in the first case lies in a plane, and in the second in a circle, and the counterbalance, while it may remedy the trouble to some extent in the line of reciprocation, adds an equal fault in a plane at right angles.

There is, also, in reciprocating machinery a constant struggle between two conditions directly in antagonism—to avoid weight and secure strength. The parts require great strength to resist and overcome their momentum, as well as to perform their work. To avoid momentum we can only reduce the weight.

The difficulties of reciprocating motion is met with in wood-cutting machinery more than anywhere else, because of the speed at which such machines require to be run. So great has been this trouble, that in machines of this class there has been a constant effort to perform their functions by rotary movement, and it is safe to assume that, if in twenty years to come there will be as much accomplished as in twenty years past, there will be but few machines with reciprocating action left.

Fig. 1.



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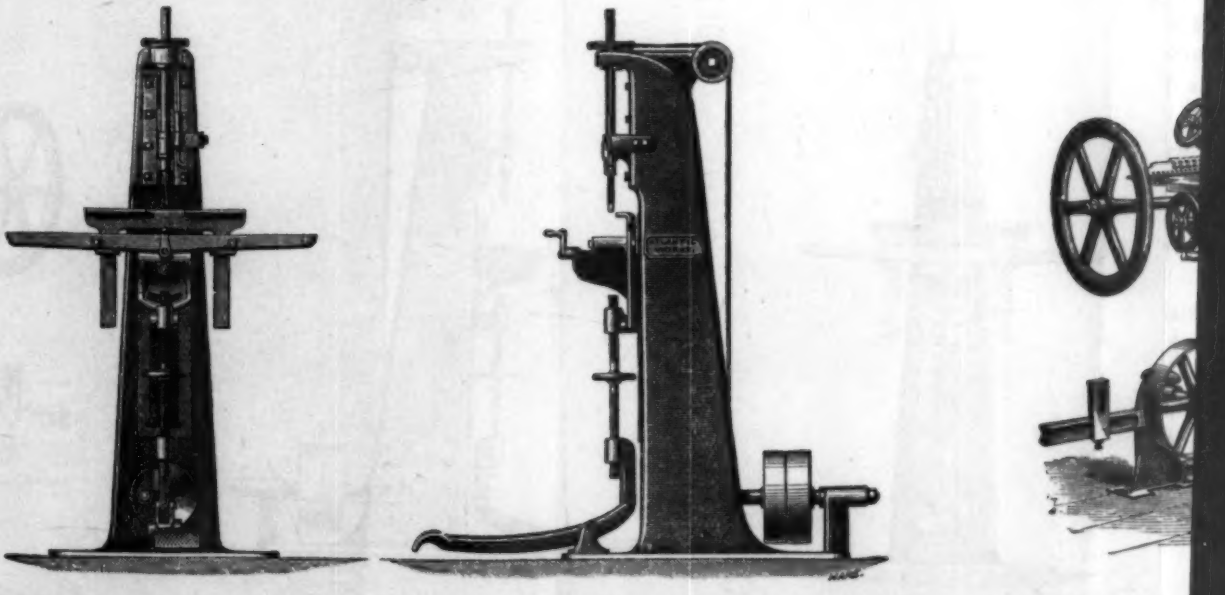

RECIPROCATING MORTISING AND BORING

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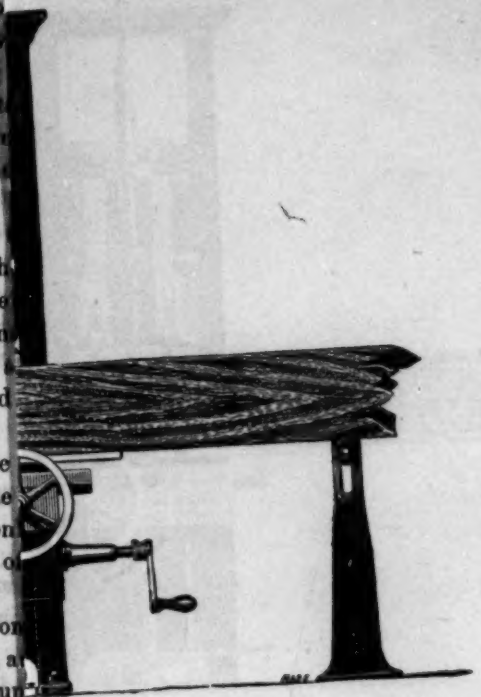
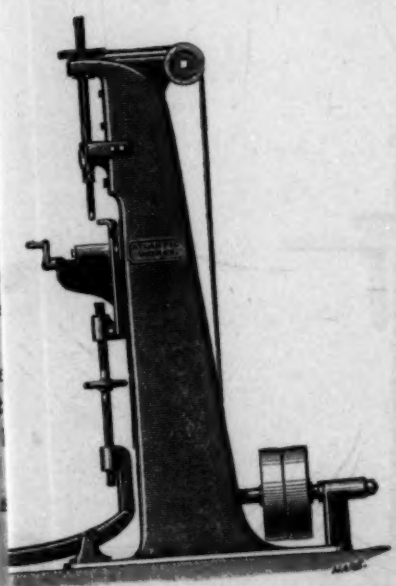
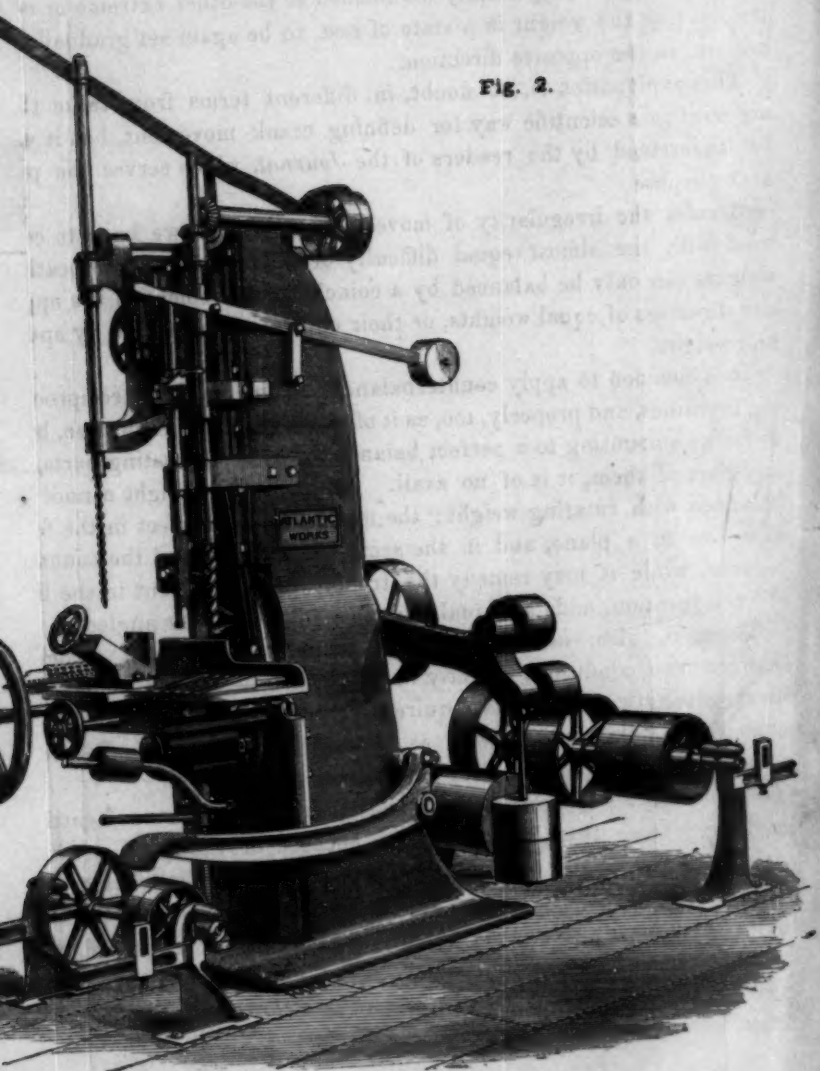


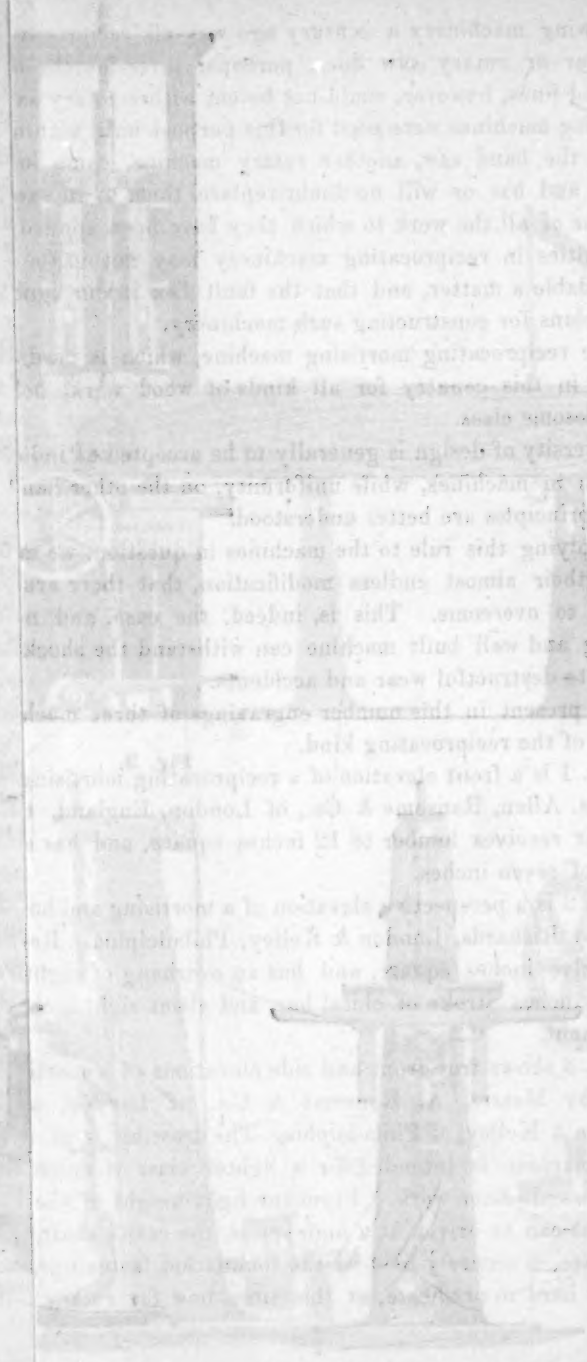


RECIPROCATING MORTISING AND BORING MA

Fig. 2.



RING MACHINE.



Sawing machinery a century ago was all reciprocating; now the circular or rotary saw does, perhaps, three-fourths of the work. Curved lines, however, could not be cut with a rotary saw, and reciprocating machines were used for this purpose until within a few years, when the band saw, another rotary machine, came in to supplant them, and has or will no doubt replace them to an extent of three-fourths of all the work to which they have been applied; so that the difficulties in reciprocating machinery may not in the end prove so formidable a matter, and that the fault lies in our ignorance of the true plans for constructing such machinery.

The reciprocating mortising machine, which is used almost exclusively in this country for all kinds of wood work, belongs to this troublesome class.

Diversity of design is generally to be accepted as indicating imperfection in machines, while uniformity, on the other hand, shows that their principles are better understood.

Applying this rule to the machines in question, we must conclude, from their almost endless modification, that there are some serious faults to overcome. This is, indeed, the case, and nothing but a strong and well built machine can withstand the shock and jar that tends to destructful wear and accidents.

We present in this number engravings of three machines for mortising of the reciprocating kind.

Fig. 1 is a front elevation of a reciprocating mortising machine, by Messrs. Allen, Ransome & Co., of London, England, to a scale of $\frac{1}{24}$. It receives lumber to 12 inches square, and has a chisel movement of seven inches.

Fig. 2 is a perspective elevation of a mortising and boring machine, built by Richards, London & Kelley, Philadelphia. Receives lumber to twelve inches square, and has an overhang of eight inches, with seven inches stroke of chisel bar, and about eight inches of vertical movement.

Fig. 3 shows true front and side elevations of a mortising machine, built by Messrs. A. Ransome & Co., of London, and Richards, London & Kelley, of Philadelphia. The drawing is of a scale of $\frac{1}{24}$. This machine is intended for a lighter class of mortising, such as cabinet and joiner work. From the light weight of the reciprocating parts, it can be driven at a high speed, the crank shaft, being in the also base, is securely held by the foundation fastenings.

It is hard to predicate, at this time, how far rotary mortising ma-

chines may supersede the use of reciprocating machines, but, judging from the tendencies of ten years past, in England, France and America, there is no doubt but that the rotary machines will be more extensively used in our shops, in the future, especially for the heavier kinds of work.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 332, Vol. lxiii.)

"*The transmission of power from motors to machines.*—It will be instructive to you as superintendents of the present improved machinery of mills, to look back on the imperfect modes of transmitting power, early used in the commencement of the cotton manufacture in New England.

"So cheap and abundant was water power then, that steam power was not at first resorted to.

"It was deemed necessary to locate a mill directly over the water-wheels; so that a main upright shaft might be arranged upward through the several stories, to transmit the power more directly to a main horizontal shaft in each room, to distribute power to each machine.

"The shaftings were all made square, to receive the cast-iron wheels fastened by wedges. The pulleys were made of wood, by clamping together pieces of joists, notched to fit the shafts, by means of screw-bolts. Instead of the numerous light pulleys now used, long wooden drums were built around the shafts, and made of boards nailed upon circular plank heads. With the slow speed of forty or fifty turns per minute, some of these drums were necessarily made three or four feet diameter and several feet long, darkening the rooms by their ponderous magnitudes, and requiring very high ceilings to admit them.

"These great drums being frailly nailed together, and unbalanced, could not be used with quick revolving movements, without shaking them to pieces, and also shaking the floors intolerably.

"This was the style of mill shafting and pulleys in use when I first commenced building a mill at Allendale, in the year 1822.

"Cast-iron pulleys, clamped upon the shafting, were soon after introduced, with their faces smoothed by grinding on stones. Round iron shafts were deemed a great improvement, with drilled wheels and

pulleys fitted to them. With these advantages, the speed of the horizontal shafts was augmented to produce eighty or ninety revolutions per minute. Early experiences of the troublesome difficulties in operating a manufactory, resulting from the imperfect modes of mill gearing then in use, excited an impatience of longer enduring.

"*The disadvantages of transmission of power from motors to machines, with slow speed.*—In all calculations of the strength of shaftings, wheels and pulleys, there is a certain relationship between the velocity of their movements and transmission of power. A belt, shaft or a pulley, that makes one revolution to do the same work which is done by another making two revolutions, has double the stress imposed upon it, and must have double the strength. By doubling the speed there is an opportunity of economizing the weight and costs of the materials employed for mill gearing, in a somewhat corresponding ratio. These are strong incentives to incite us to attempt improvements of transmission of power in all manufactories.

"In the functions of the mechanisms of all animals, the most admirable scientific skill is displayed in adapting the proportion of bone and muscle to the speed of movement designed to be accomplished. These are models for study, presented to the engineer for copying, in artificial mechanisms for transmitting power. The slender limbs of the deer, of the greyhound, and race-horse, all designed for fleet movements, show an impressive contrast with those of the elephant or the heavy draught horse.

"Instead of increasing strength of wheels and pulleys by additions of more metal, when they are to be used with a higher speed, they become less fit for turning with swift velocities. They may even fly into pieces by the tendency of this excess of matter to move in a straight line, recognized as 'centrifugal force.'

"To duly apportion the formation of the parts of all machines for the transmission of power, is the scientific task assigned to engineers. In addition, there is requisite a knowledge of the various properties of strength, elasticity and hardness to endure wear, and other qualities. Even changes of temperature, with consequent expansion and contraction of metallic parts, is not to be overlooked. The imperfections of settling foundations, by disarranging the best fitted lines of strong shafting, may cause them to fail of durably transmitting power from motors to machines. The very rigidity of the parts, resulting from the great size of shaftings requisite for transmitting power with slow velocities, is a principal cause of their failure, where light and flexible

shafting, with high velocities, might durably perform the service. I will here give you a remarkable illustration of the actual results of transmitting power by mill gearing, with slow speed, by the strongest shafting, made without regard to cost for securing durability of service.

"In persistently carrying out the old system of heavy shafting with slow velocities, in a large cotton mill built in Connecticut, in the year 1857, the attempt was made to transmit the power from four large water-wheels through a line of cast-iron shafting of the great diameter of 12 inches, made in sections of ten feet in length; each piece weighing 3,500 pounds, with couplings of the weight of 3,800 lbs. each. So great was their weight and rigidity, that the settlings of the foundations, changes of temperature and continual jar, caused them to break so frequently as to render necessary the replacement of them by new wrought iron shafts. Quite recently these, in turn, have been discarded as unsatisfactory; and are superseded by light, quickly-revolving shaftings, driven by belts from pulleys 20 feet diameter, and 24 inch face, with a surface velocity of over 5,000 feet per minute. All that was practicable to perfect the old system of slow speed of mill gearing was here done to maintain a dying struggle for its prolonged existence.

"*Experiments for testing the advantages of transmitting power with high velocities.*—Having realized from practical experiences the disadvantages of the slow speed system, more than twenty years previously to this persistent attempt to perpetuate it, an entirely opposite system was commenced by me in the construction of a second mill at Allendale, in the year 1839. The idea was there carried out, of more than doubling the then existing speed of mill shafting, from 90 revolutions to over 200 per minute, for the special purpose of reducing the size and weight of all the shafting and pulleys in nearly a corresponding ratio, with the economy of costs and motive power.*

"To accomplish this object, several important innovations were necessary upon the old modes of transmitting power. A wheel pit was requisite outside of the mill building, in a separate wheelhouse, for the double purpose of obtaining more space for larger cog-wheels, to get up the requisite speed, and of excluding the noxious steamy dampness arising from all water wheels shut up within the mill walls.

* David Wharton, then my partner, said he "washed his hands of this responsibility." He lived, however, to be baptized in it.

"The pulleys in previous use, with ground or turned surfaces, would not operate quietly, without being turned inside as well as outside, to balance the rims, and prevent the tremor consequent on the use of all unbalanced pulleys revolving rapidly. This improvement also reduced the weight of the pulleys to correspond with the reduced weight of the shafting and wheels, made of half the previous diameters, excepting those used in the wheel pits of larger size to get up speed.

"Before this systematic balancing of pulleys was commenced, no inconsiderable portion of the power was transmitted to shake the floors and even to cause some of the old wooden mills to rock to and fro. This experiment, deemed somewhat wild at the time, proved successful. It has gradually been adopted as an economical system of transmitting powers from motors to machines by high velocities of shafts and belts.

"In constructing a third mill in Georgiaville, in the year 1858, a further attempt was made to more than double the speed again, and to still further economize the weights and cost of materials and power used.

"The details of the experiments there made and practically applied, you have requested me to give an account of, as facts that may serve usefully for guidance hereafter to others, in further perfecting the transmission of power for operating the machinery of mills."—*From Proceedings of New England Cotton Manufacturer's Association, No.* 10, *April* 19, 1871.

(To be continued.)

EXPERIMENTS ON VARIOUS COALS OF THE CARBONIFEROUS AND CRETACEOUS PERIODS,

To Ascertain their Relative Potential and Economic Vaporizations. Made by Chief Engineer B. F. Isherwood, *U. S. Navy, at the Mare Island Navy Yard, California, in* 1871.

(Continued from page 402, Vol. LXIII.)

Boiler.

The boiler is of the direct-flue type—that is, has flues in direct continuation of the furnace—with the gaseous products of combustion returned beneath the shell in a flue of masonry which contains a heater connected by vertical pipes with the bottom of the shell. A portion of the boiler is composed of brick masonry.

The front portion of the boiler is rectangular with a semi-cylindrical top. Its width is 5 feet; its length in the direction of the boiler's

shell is 5 feet 8 inches. Its height, exclusive of its ash-pit, which is made of masonry, is 8 feet 2 inches. The depth of the ash-pit additionally is 1 foot 2 inches.

The back portion of the boiler is a cylinder 3 feet 6 inches in outside diameter, and 18 feet 3 inches in length. Its front end is joined to the front portion of the boiler by a curve of 12 inches radius, and its back end is flat. The axis of this cylinder is 5 feet 3 inches below the top of the front portion of the boiler. The aggregate length of the front and back portions of the boiler is 23 feet 11 inches.

The front portion of the boiler contains a furnace 4 feet wide and 4 feet 6½ inches long. Its top is flat, and 2 feet 3 inches above the top of the grate bars. The top of the grate bars is 1 foot 1 inch above the bottom of the front portion of the boiler. The sides and back of the ash-pit are of brick masonry; and the depth of the ash-pit below the bottom of the front portion of the boiler is 1 foot 2 inches. The flat water-spaces at the sides of the furnace are 6 inches wide, including thicknesses of metal; and, at the front and back of the furnace, 6¾ inches wide, including thicknesses of metal. The opening for the furnace-door is rectangular, 13½ inches high and 18 inches wide. The bottom of this opening is 17 inches above the bottom of the front portion of the boiler. The furnace door is of wrought iron, with a wrought iron lining plate; and both door and lining plate are perforated with thirty holes, ½ inch in diameter, for the admission of air above the incandescent fuel. The grate bars are horizontal.

From the back of the furnace to the back end of the cylindrical portion of the boiler, extend horizontally two cylindrical flues of 15 inches inside diameter and 18 feet 9¾ inches extreme length. The water spaces between the flues, and between them and the boiler shell, are 2½ inches wide in the clear. The axes of the flues are in a horizontal plane 6 inches below the axis of the cylindrical shell.

After leaving the cylindrical flues, the gaseous products of combustion descend through a back smoke connection of brick masonry, into a lower horizontal flue of brick masonry, whence they return beneath the cylindrical portion of the boiler shell to the front portion of the boiler shell, where, after passing over a brick wall, they again descend into a horizontal conduit of brick masonry which delivers them into the chimney.

The back smoke connection is rectangular in form, 20 inches long in the clear lengthwise the boiler, and 4 feet 4 inches wide in the clear crosswise the boiler. Its top is arched to a radius of 3 feet 9 inches.

This arch is 8 inches deep, and its top is in the same plane with the top of the cylindrical portion of the shell.

The lower horizontal flue of brick masonry is rectangular, 4 feet 4 inches wide in the clear, and 17 feet 3 inches long from the back of the back smoke connection. Its height, to a plane passing through the axis of the cylindrical portion of the boiler shell, is 5 feet 3 inches in the clear. At the front end of this flue is a brick wall 12 inches thick, with its horizontal top 6 inches below the bottom of the cylindrical portion of the boiler shell. On the opposite side of this wall is a vertical flue 4 feet 4 inches wide in the clear, 18 inches long lengthwise the boiler, and 3 feet deep from the top of the wall. This vertical flue delivers into a horizontal conduit of brick masonry 18 inches wide and 2 feet high, with an arched top of 15 inches radius. This conduit carries the products of combustion into the chimney, and is about 36 feet in length.

The brick masonry of the ash pit and of the conduit delivering the products of combustion into the chimney is 9 inches thick, the remainder of the brick masonry is 13½ inches thick, and between the side walls it is carried up and over the cylindrical portion of the boiler shell.

In the horizontal flue of brick masonry, beneath the cylindrical portion of the boiler shell, is placed a heater, which is a cylinder of plate iron, 20 inches in outside diameter and 18 feet in length. Its front end is a segment of a sphere of 20 inches radius, and its back end is flat. This end is in the plane of the outside of the brick wall forming the back of the back smoke connection, and the feed-water pipe connects to it by a suitable flange. The heater is slightly inclined, the top of its front end being 9 inches from the bottom of the cylindrical portion of the boiler shell; thence it descends 9 inches from the horizontal to its back end. The heater is connected to the cylindrical portion of the boiler shell by four vertical pipes of 10 inches outside diameter, placed equidistant 4 feet 6 inches between axes. The axes of the heater, of the connecting pipes, and of the cylindrical portion of the boiler shell, are in the same vertical plane.

In the top of the cylindrical portion of the boiler shell is a man-hole, and there is another in the back part of the front portion of the boiler shell above the cylindrical portion, and as high as it could be placed. To this man-hole the escape pipe for the steam during the experiments was attached.

The front portion of the boiler was covered with thick new felt,

stitched upon canvas, and the back portion was completely encased in brick masonry, no portion being exposed to the atmosphere.

The chimney, which was of brick masonry and very lofty, was in common with another boiler, with the forges of the smithery, and with other uses, its cross area being proportionally large.

The following are the principal dimensions and proportions of the boiler:

Length occupied by boiler, including masonry at end, 26 feet 9 inches.

Breadth occupied by boiler, including masonry at sides, 6 feet 8 inches.

Height occupied by boiler, from bottom of masonry flue containing the heater, 10 feet 8 inches.

Length of the grate bars, 4 feet 6½ inches.

Breadth of the furnace, 4 feet.

Area of grate surface, 18⅜ square feet.

Heating surface in furnace, 52·65 square feet.

Heating surface in the two cylindrical flues, 147·26 square feet.

Heating surface in the boiler shell, 110·49 square feet.

Heating suface in the heater and its connecting pipes to boiler shell, 99·60 square feet.

Total water-heating surface, 410·00 square feet.

Cross area of the two cylindrical flues, 2·454 square feet.

Cross area of the brick flue delivering products of combustion into the chimney, 2·750 square feet.

Aggregate area of the 30 air holes in the furnace door, 5·890 square inches.

Water space up to 4 inches above crown of furnace, 149 cubic feet.

Steam space above 4 inches above crown of furnace, 138 cubic feet.

Ratio of the heating to the grate surface, 22·569 to 1·000.

Ratio of the grate surface to the cross area of the two cylindrical flues, 7·411 to 1·000.

Ratio of the grate surface to the cross area of the brick flue delivering products of combustion into chimney, 6·606 to 1·000.

The experiments were made in the following manner, namely:

Manner of Making the Experiments.

The boiler was situate on the floor of the boiler house (a completely inclosed brick building), and was so arranged that any leak from it would be immediately discovered. All its parts exposed to the air

which were not cased in brick masonry, were covered with new thick felt stitched upon canvas. The man-hole plate in the upper part of the front portion of the boiler was removed, and a sheet iron pipe of 8¼ inches inside diameter fitted to it for the escape of the steam. This pipe rose vertically 5 feet from the man-hole, and then extended with a slight downward inclination from the horizontal 2½ feet; thence it descended vertically 4 feet, after which it was carried 20 feet, to the outside of the building, in a straight line slightly inclining downward. A tank was placed beneath its outer extremity to receive all the water foamed or primed from the boiler, and all the water due to the condensation of the steam in the pipe. A careful and long trial, conducted with a rate of evaporation under the atmospheric pressure which prevented the slightest approach to foaming, gave, as the measure of the condensation per hour of the steam by the surface of the pipe, when surrounded by still air of the temperature of 68 degrees Fahrenheit, 0·17 cubic feet of water at the same temperature. Whenever the quantity of water caught in this tank exceeded that amount, the excess was considered as due to foaming, and deducted from the vaporization as given by the feed-water tanks, allowing for the thermal effect due to the difference of its temperatures in those tanks and in the boiler. The quantity of water foamed was but slight at the maximum, and would not have sensibly affected the economic comparison of the coals had it been entirely neglected.

Before commencing the experiments, the boiler was tested under a hydrostatic pressure of 60 pounds per square inch, and found perfectly tight. The lower joint of the blow-off valve chamber was broken, and a blank flange bolted on to prevent the possibility of leakage at that place.

The evaporation was performed under the atmospheric pressure, the steam escaping freely through the man-hole and its attached pipe. At the end of each experiment, the boiler and its flues were thoroughly swept of soot and ashes. A glass water-gauge of the usual construction was attached to the boiler; and the water, by its indications, was kept at the uniform height of 6 inches above the top of the furnace at the commencement, during the continuance, and at the end of each experiment.

The feed-water, previously to being delivered in the boiler, was accurately measured in two tanks, made of wood and smoothly lined with sheet lead. These tanks were exactly rectangular, and each held 164 cubic feet of water. They were placed in the boiler house on wooden

trestles, with their bottoms, accurately levelled, several feet above the top of the boiler, so that the water flowed by gravity from them into the latter. Beneath the bottom of each tank was bolted a screw valve, from which a feed-pipe led to the boiler; the two pipes, one from each tank, forming a junction before reaching the boiler which was entered through another screw valve at the back end of the heater. By this last valve the attendants in the fire room were enabled to regulate the supply of feed-water so as to maintain it constant at the given height in the glass gauge. The office of the valve on the bottom of the tank was merely to shut off that tank while it was being filled. The entire tank and feed-pipe were in full view, and the slightest leakage could not escape instant discovery. The tanks were filled by a donkey steam pump, with rain water from the machine shop cistern, and they were filled each time to overflowing.

Every pound of coal thrown into the furnaces was accurately weighed on one of Fairbanks' platform scales, carefully tested. The tub in which the coal was weighed was of iron; it was precisely counterbalanced on the scale, filled each time to the same weight, and noted the moment it was emptied. In the case of the anthracites, the lumps were made of the uniform size of about 2½ inches cube, and only lumps were used. In the case of the other coals, the lumps were reduced to the same dimensions, but the fine as well as the lumps were used.

The refuse from the coal in clinker, ashes, soot and dust was weighed upon the same scales, in the same manner, and in the dry state. The clinker was picked out and weighed separately, after which the remaining refuse was weighed. The iron tub in which all the weighing was done was of 4¼ cubic feet capacity, and by it there were determined the weight per cubic foot of the coal, of its clinker, and of its ashes. The true specific gravity of the clinker, or its specific gravity exclusive of its air-cells, was obtained by first weighing a tub full of it, and then filling the interstices of the clinker with water to the top of the tub, and weighing the mixture, when the one weight deducted from the other gave the weight of water in the tub, the bulk in cubic feet corresponding to which having been ascertained for its temperature and subtracted from the number of cubic feet in the tub, the remainder was the number of cubic feet occupied by the known weight of clinker, from which its true specific gravity, compared with water at the temperature of 39 degrees Fahrenheit as unity was easily deduced. The true specific gravity of the coke was obtained in like manner, but that of the coals was determined by weighing in and out of water on a very delicate apothecaries' scales.

The experiments were conducted in the following manner, namely: Before commencing each experiment, every part of the fire-surface of the boiler was swept clean of soot, dust and ashes, and the boiler filled with water to the proper height. The water was raised to the boiling point with wood, which was then allowed to burn down to the few embers required to kindle the coal. The height of the water in the boiler was now adjusted on the glass gauge, the tanks filled, the time noted, the coal fired, and the experiment held to commence. At the end of the experiment the water was adjusted, by admission, to precisely the same level in the boiler as at the commencement.

It was the intention to have made three experiments with each variety of coal, and with the coke; the first at the maximum rate of combustion, the second at the medium rate of combustion, and the third at a slow rate of combustion; these rates in the last two being kept as nearly the same as possible for all the coals and the coke, so that the comparison of their calorific values by means of this condition might be exact, which could not be the case with the maximum rate of combustion, on account of its great difference with the different coals and the coke. Had the boiler possessed a sufficient quantity of heat-absorbing surface to reduce, at all the different rates of combustion, the gaseous products of the combustion of the different coals and the coke to the same temperature when leaving it, then the economic vaporation would not have been affected by the rate of combustion; but, as this was not the case, the true relative calorific values must be obtained from those experiments in which the rate of combustion was nearly equal; the experments with the maximum rate of combustion giving only the maximum quantity of steam that could be obtained from the different coals and the coke in equal time with the experimental boiler, and without regard to the economy of the fuel. This intention, as regards making three experiments with each kind of coal and the coke, was carried out in all with the exception of the Queen Charlotte Island anthracite, of which only a sufficient quantity could be obtained for one experiment corresponding to a slow rate of the *combustible portion* of the anthracite—that is, of the portion which remains after deducting the ash and clinker.

It was also the intention that each experiment should continue exactly twenty-four consecutive hours, and this was carried out with the exception of the following ones, of which the duration was less because of a deficiency in the quantity of coal and coke furnished, namely: The experiment with Queen Charlotte Island anthracite,

which continued 22 consecutive hours; the experiment with slow combustion made on Mount Diablo brown coal, which continued 11½ consecutive hours; the experiment with slow combustion made on Coose Bay brown coal, which continued 19¾ consecutive hours; the experiments with maximum and slow combustion made on the Seattle brown coal, which continued, respectively, 21 and 7 consecutive hours; the experiment with slow combustion on Bellingham Bay brown coal, which continued 17 consecutive hours; and of that made with medium combustion on coke, which continued 16¼ consecutive hours.

During the experiments with the brown coals, grate bars were employed of ½ inch width with $\frac{3}{16}$ inch wide air spaces, to prevent the loss of the small pieces. With the other coals the grate bars were ¾ inch wide with ⅜ inch wide air spaces.

Throughout each experiment the fires were maintained at the thickness of 7 inches on the grate, kept leveled and free from holes. They were cleaned at regular intervals, and in the same manner, and to the same extent. The holes in the furnace door were kept open throughout. For the last half or three-quarters of an hour of each experiment, according to circumstances, the coal was allowed to burn down, so that but little remained on the grate at its close; and the moment the twenty-four hours expired, the fires were drawn and the unconsumed coal picked out from the ashes, weighed separately, and deducted from the amount expended. The refuse in ashes, clinker, &c., was also weighed, together with the sweepings of the fire-surface of the boiler, and the amount added to what was withdrawn from the ash-pit and furnace during the experiment. Each coal was tried with its maximum rate of combustion, to determine the absolute quantity of steam it would produce in a given time, without reference to economy; and with the uniform rate of combustion of about eleven pounds of its combustible matter per square foot of grate surface per hour, to determine its economy with equal rate of combustion.

The pressure of the steam in the boiler above the atmosphere was ascertained by a delicate mercurial siphon gauge of glass, the height of the mercurial column being measured from the level of the mercury in one leg of the siphon to its level in the other leg.

Every care was taken to have all the conditions in the different experiments as nearly alike as possible, and the same experienced firemen and attendants were employed throughout.

During each experiment a tabular record was kept, in which was noted, hourly, the temperature in degrees Fahrenheit of the external

atmosphere in the shade, of the fire room, and of the feed-water in the tanks; also, the pressure of the atmosphere in inches of mercury as given by a tested aneroid barometer, and the pressure of the steam in the boiler above the atmosphere as given by the mercurial siphon gauge. In its proper column was entered the exact minute at which each tankful of feed-water was emptied; and, in appropriate ones, the weights of coal, clinker, ashes, &c. The temperature of the gaseous products of combustion when leaving the boiler could not be ascertained, as, in every case, except the slow combustion, it was above 600 degrees Fahrenheit, the limit of the mercurial thermometer.

The data and results of the experiments made as above narrated, and with the boiler, and on the coals described, have been arranged in the following tables, numbered 1 and 2, the quantities of which were obtained in the manner explained below.

(To be continued.)

THEORY OF CONTINUOUS BEAMS.

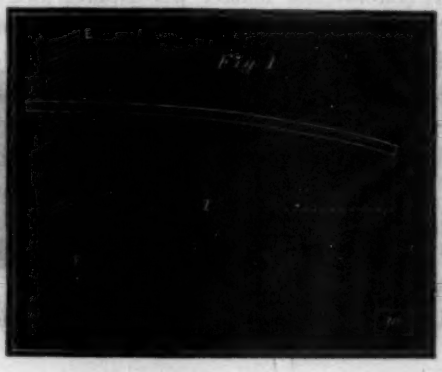
By Jos. P. Frizell, C. E.

Navier, one of the clearest writers upon the resistance of materials, was also one of the first to employ the principles of the elastic curve in determining the deflection and ultimate strength of beams. He considered the case of a beam loaded uniformly or otherwise, and

1. Supported at both ends.
2. Fixed at one end and free at the other.
3. Fixed at one end and supported at the other.
4. Fixed at both ends.

These four cases are all that have been discussed by those who have followed the methods of Navier, and this includes nearly all writers upon this subject up to a quite recent date.

The case of a beam fixed at one or both its ends, is an approach to the theory of continuous beams, although the usual method of treating it is calculated to obscure that fact. A beam is spoken of as fixed at any point, when it is meant that the tangent to its elastic curve, at that point, is maintained in a horizontal



position. It is assumed that this condition is fulfilled by imbedding the beam in a wall, as indicated at Fig. 1, the length of the beam being reckoned from the face of the wall, or the tangent to the beam, at its junction with the wall, being supposed horizontal. This mode of treating the subject is objectionable upon two grounds. 1. It involves a grave misconception, viz., that two opposite forces, acting in the same line, E F, can resist the moment of the force, w, acting at a distance, l, together with the weight of the beam, which could only be the case if the two opposite forces were infinite. 2. It fails to carry the mind beyond the point of supposed fixedness.

The only mode in which the conception of a beam fixed at any point can be realized, is the one indicated at Fig. 2, viz., by allowing the beam to extend past the point, which must be a supporting point, and applying a sufficient force at a finite distance therefrom. Had Navier contemplated the subject under this form, his acute mind would, no doubt, have been led directly to the theory of continuous beams.

The principles of continuous beams apply to bridge girders which extend unbroken over two or more openings; to lines of shafting; to all beams supported at more than two points.

To make this article complete in itself, and relieve the reader from the necessity of consulting other works in explanation, it will be necessary to develop some of the chief propositions in the general theory of beams.

Let A C, Fig. 3, represent a portion of a beam, one extremity resting at A, loaded in any manner, subject to the condition that the intensity of the load, at any point, is a function of its distance from A. Let X represent the longitudinal force or strain of extension or compression upon any fibre of the beam in the section, D E, at a distance,

x, from A; y, the distance of such fibre from C, the neutral fibre. The sum of the moments of these molecular forces with reference to C, will be an expression of the form $\Sigma X y$. Let A represent the pressure on the support, A. Let V = the shearing force in the section E D, or the vertical force acting upon A C in consequence of its connection with the portion to the right of E D. The weight of the portion A C will be represented by $\int_0^{x_1} w\,d\,x$, in which w is a function of x_1. The forces acting upon A C in a downward direction are equal to those acting upward, or

$$A = V + \int_0^{x_1} w\,d\,x, \text{ whence } V = A - \int_0^{x_1} w\,d\,x. \qquad (1)$$

$\Sigma X y$ is the moment with reference to C of the resistance to bending developed in the section E D. It is also the moment with reference to A of the forces tending to turn A C around A to the left.

For, let X_1 represent the sum of the forces of extension acting in E D;

a, the distance of their resultant from C;

X_2, the sum of the forces of compression;

b, the distance of their resultant from C;

c, the perpendicular from A upon the direction of X_1.

Then $a X_1 = b X_2$, a relation implied in the supposition that C is the neutral fibre. Whence $\Sigma X y = a X_1 + b X_2 = 2 a X_1$, X_2 may be replaced by a force, X_1 acting at a distance a from C without altering the moments with reference to C. The moments with reference to A are, therefore,

$$(c + 2 a) X_1 - c X_1 = 2 a X_1 = \Sigma X y.$$

The moments of the forces tending to turn A C around A, to the left, are equal to those tending to turn it in the opposite direction, or

$$\Sigma X y = \int_0^{x_1} w x\,d\,x = V x_1. \qquad (2)$$

Equation (1) enables us readily to find the value of V. Suppose an abscissa a, so chosen that $A = \int_0^a w\,d\,x$, in which case Va, the

shearing force corresponding to a, would be o. Then, by eq. (1), $V = \int_o^a w\,d\,x - \int_o^{x_1} w\,d\,x$, or

$$V = \int_{x_1}^{a} w\,d\,x. \qquad (3)$$

That is, the value of V for any abscissa x_1 is equal to the weight of the portion $a - x_1$ of the beam, or equal to the weight between x_1 and the point where $V = o$. It is evident that the maximum value of V is at the supporting point, where $V = A$.

Differentiating (1) and (2) with reference to x and V, observing that x and x_1 being both independent variables $dx_1 = dx$ $aV = -w\,dx_1$. $d\,\Sigma\,X\,y = w\,x_1\,dx_1 + V\,dx_1 + x_1\,dV$, whence

$$\frac{d\,\Sigma\,X\,y}{dx_1} = V \qquad (4)$$

An important consequence results directly from eq. (4), viz., that $\Sigma\,X\,y$ attains its maximum value where $V = o$, or that the breaking point occurs where the shearing force is null. It is also evident that the minimum value of $\Sigma\,X\,y$ occurs at A, or that the maximum value of V corresponds in position with the minimum value of $\Sigma\,X\,y$.

A thorough comprehension of the nature of shearing force is essential to a clear idea of the theory of counterbracing in trussed girders, which are beams composed of longitudinal chords for resisting the tensile and compressive forces, and ties and pillars for resisting the shearing force. From an inspection of Fig. 3, it will appear that for a value of x_1 between o and a, the shearing force acts downward with reference to A; that is, it tends to turn A C around A to the right. For a value of x_1 greater than a, the shearing force acts upward with reference to A, or it tends to prevent A C from turning around A to the right. Under the action of moving loads, the breaking point (defined by the abscissa a) shifts its position, within certain limits, depending upon the ratio of the moving to the fixed load. Within these limits the truss must be capable of resisting both an upward and downward direction of the shearing force. This object is attained in the system with upright pillars and sloping ties, by a double set of ties, sloping in contrary directions; in the system with upright ties and sloping pillars, by a double set of pillars, sloping in contrary directions; and in the so-called triangular system, by making the same member capable of serving both as tie and pillar. Neither of these dispositions, however, is necessary outside of the extreme positions of the breaking point.

The internal force, $\Sigma\,X\,y$, is called into action by any external

force acting perpendicularly to the length of the beam. The beam thereby undergoes a bending, the fibres upon the concave side being shortened and those upon the convex side extended. This extension and compression is greatest for the external fibres, and diminishes internally, where there must exist a fibre subject to neither extension nor compression, called the neutral fibre. There is, in reality, a series of such fibres extending through the beam in a direction perpendicular to the plane of the bending forces, so that "lamina" is a more proper term than "fibre." There is nothing gained in the way of perspicuity, however, by preserving this distinction. This neutral fibre, or line, forms for the entire beam what is termed the elastic curve.

To estimate the extension or compression, it is assumed that any section of the beam, normal to the neutral line before bending, remains so after bending. This assumption, though in some degree hypothetical, leads, nevertheless, to results agreeing sufficiently well with those of experiment.

All materials used in construction are susceptible, in a greater or less degree, of extension and compression. Within certain limits, which should never be exceeded in practice, the relative extension corresponding to a given tensile force per square inch is equal to the relative compression, for a compressive force of equal intensity. In comparing one material with another, as regards elasticity, a prism of each material is supposed, usually one square inch in section, and one linear unit in length. The elasticity of the material is represented by the ratio of any force applied to this prism, to the extension or compression caused by it. This quantity is represented by E, and is constant for each class of material.

Let A B, Figure 5, represent a portion of a beam, exposed to the action of bending forces as shown. Let M N represent an indefinitely small portion of the neutral line. O M = R, the radius of curvature corresponding to the element M N. The lines O P, O S, were parallel to one another before bending. Let a represent the distance M P; b, the dis-

tance M L. Let c d be a fibre at a distance y from M N, and z the corresponding thickness of the beam, perpendicular to the plane A B O. c d was equal to M N before bending, and c d — M N represents the extension due to the bending force.

$E \frac{c\,d - M\,N}{M\,N} z\,d\,y$ is the tensile force developed in c d.

By similar triangles O M : O C = M N : c d,

$$\text{or } c\,d = \frac{M\,N \times O\,C}{O\,M} = \frac{M\,N\,(R+y)}{R} = M\,N\left(1 + \frac{y}{R}\right)$$

and the tensile force developed in c d is $\frac{E}{R} z\,y\,d\,y$. In the same manner we should find for a fibre at a distance y below the neutral line, a precisely equal compressive force. We have, therefore, for the total force of extension,

$$\frac{E}{R}\int_0^a z\,y\,d\,y, \text{ and of compression, } \frac{E}{R}\int_0^b z\,y\,d\,y.$$

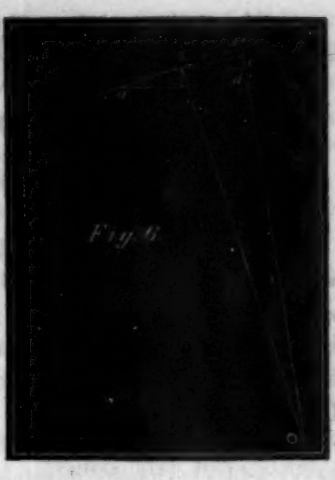
As no external force acts upon the beam in a horizontal direction, the internal forces of extension and compression must balance one another, or

$$\frac{E}{R}\int_0^a z\,y\,d\,y = \frac{E}{R}\int_0^b z\,y\,d\,y \text{ or } \int_0^a z\,y\,d\,y = \int_0^b z\,y\,d\,y,$$

whence it is apparent that the neutral line passes through the centre of gravity of the section.

The moment of the force developed in c d with reference to the point M is $\frac{E}{R} z\,y^2\,d\,y$, and the total moment of the resistance to bending in the section P L is $\frac{E}{R}\left(\int_0^a z\,y^2\,d\,y + \int_0^b z\,y^2\,d\,y\right)$. The expression within the parenthesis is the moment of inertia of the section, and is usually represented by I. We have, therefore, $\frac{E\,I}{R}$ for the moment of resistance to bending hitherto represented by $\Sigma\,X\,y$; or, putting M to represent the sum of the moments of the external forces with reference to the point M,

$$\frac{E\,I}{R} = M \qquad (5)$$



It remains to find an expression for R, the radius of curvature, in terms of the co-ordinates of the curve. Let a b b c be two consecutive elements in a plane curve. b o = R, the radius of curvature corresponding to b c. b d = d x, d c = d y, c e = the difference between two consecutive values of d y = d ²y. Draw c f perpendicular to b e. e b d is the angle whose tangent is $\frac{d\,y}{d\,x}$. By similar triangles o b : b c = b c : c f, whence R

$$= \frac{b\,c^2}{c\,f} = \frac{d\,x^2 + d\,y^2}{d^2y \cos e\,b\,d}$$

$$= \frac{d\,y^2 + d\,x^2}{d^2y} = (d\,y^2 + d\,x^2)\sqrt{1 + \left(\frac{d\,y}{d\,x}\right)^2} = \left(1 + \left(\frac{d\,y}{d\,x}\right)^2\right)^{\frac{3}{2}}$$

$$\sqrt{1 + \left(\frac{d\,y}{d\,x}\right)^2} \qquad d^2y \qquad \frac{d^2v}{d\,x^2}$$

As the flexure of beams is, in all cases, very small, $\frac{d\,v}{d\,x}$ is the tangent of a very small angle, and $\left(\frac{d\,y}{d\,x}\right)^2$ may safely be neglected in comparison with unity. Eq. (5) thus becomes $E\,I\,\frac{d^2v}{d\,x^2} = M$ (6) which is the fundamental equation of the elastic curve.

(To be continued.)

A New Source of Potash.—Mr. H. Hazard hazards the opinion that the cobs of the Indian corn, so largely cultivated with us, might be made available as a source of supply of this substance.* A number of analyses brought to light the fact that the cobs contain, on an average in 1000 parts, 7·62 parts of carbonate of potash; or about twice as much as the best kinds of wood. The author further states that, taking the average production of corn in the United States, there might be obtained from this source 51,612 tons yearly of carb. potassa; while at the same time a considerable quantity of chloride of potassium may be produced.

* Am. Jour. Pharm.

Chemistry, Physics, Technology, etc.

THE GREAT FIRES OF 1871 IN THE NORTHWEST.

By Prof. I. A. Lapham,
Asst. to Chief Signal Officer U. S. A.

2d Paper.

The question is often asked whether the great fires of the northwest, during the months of September, October and November, 1871, and especially the one which levelled to the ground a large share of the city of Chicago, had any decided effect upon the weather, either by creating or modifying currents of air or by causing a fall of rain. It was reported by telegram to London, England, and there published, "that this fire was chiefly checked on the third or fourth days by the heavy and continuous downpour of rain, which it is conjectured was partly due to the great atmospheric disturbances which such an extensive fire would cause, especially when we are told that the season just previous to the outbreak of the fire had been particularly dry." This was said to afford an additional example from which to judge of the truth of the so-much-disputed assertion, that extensive fires are almost invariably followed by heavy downpours of rain which have been caused by them.

A very little attention to the facts exhibited by the great fire will show that no such downpours occurred, and that the fire was checked, not by rain, but for want of other combustible material in the direction towards which the flames were driven by the wind.

The fire commenced at 9½ P.M. of Sunday, October 8th, and continued during that night and most of the succeeding day. By 2 A.M. of the 9th it had reached the Court House and the Sherman House, and was consuming the most valuable portions of the city. Twelve hours later it was ravishing Lincoln Park, in the north part of the city. The last house consumed (Dr. Foster's) was in flames at 10 P.M. Commencing at a point in the south-west part of the city, the fire moved rapidly to the north-eastward, and only ceased when it had reached the extreme north part of the city, or the shore of Lake Michigan on the east. After this time there was but little spread of the flames, though the burning buildings were not yet entirely consumed.

During all this time—twenty-four hours of continuous conflagration upon the largest scale—no rain was seen to fall, nor did any rain fall

until 4 o'clock the next morning; and this was not a very considerable "downpour," but only a gentle rain, that extended over a large district of country, differing in no respect from the usual rains. The quantity, as reported by meteorological observers at various points, was only a few hundredths of an inch. It was not until four days afterwards (14th) that anything like a heavy rain occurred.

It is therefore quite certain that this case cannot be referred to as an example of the production of rain by a great fire.

Must we therefore conclude that fires do not produce rain, and that Prof. Espy was mistaken in his theory on that subject?

By consulting his reports, it will be found that he only claimed that fires would produce rain under favorable circumstances of high dew point and a calm atmosphere.*

Both these important conditions were wanting at Chicago, where the air was almost entirely destitute of moisture, and the wind was blowing a gale. To produce rain, the air must ascend until it becomes cool enough to condense the moisture, which then falls in the form of rain. But here the heated air could not ascend very far, being forced off in nearly a horizontal direction by the great force of the wind.

The case therefore neither confirms or disproves the Espian theory, and we may still believe the well authenticated cases where, under favorable circumstances of very moist air, and absence of wind, rain has been produced by large fires.

At some localities where fires occurred of considerable extent, rain was observed to fall during their progress; but, so far as is known, these were general rains, extending equally over the country, and not produced or apparently affected by the fire.

Had these great fires occurred during a calm, doubtless many of the pnenomena described in Espy's theory—the ascending current, the in-blowing air from all directions, the cloud formation above, and possibly even rain—may have been produced; but all these were prevented, or very materially modified, by the lack of moisture and the great force of the south-west gale.

The effect of these great fires upon the currents of air was also materially modified by the great force and velocity of the south-west gale.

While it is undoubtedly true, as stated by Espy and others, that the increased temperature of the air causes it to rise, and thus pro-

* Fourth Report, 1857, p. 29.

duce an inflow of the surrounding atmosphere from all sides, it is manifest that the gale prevents an inflow from the front and increases it in the rear. Different observers represent the wind as sweeping along at a fearful rate, increasing as the fire progressed. While some report a whirling motion, others say the motion was direct.

As the flames arose above the tops of the houses, or of the forests, they were forced forward by the fierce gale. Fire-brands were carried a great distance; and even roofs of houses are said to have been lifted up and precipitated upon adjoining buildings. It was, at times, difficult for a strong man to resist the force of the wind. The approach of the fire is represented as very rapid, and accompanied by unusual sounds, increased to that of Niagara. Piles of lumber were blown away, chimneys thrown down, and sand and ashes were swept along like drifting snow.

Under these conditions, the fires of course spread with the most fearful rapidity in the direction towards which the wind was blowing, its velocity being such as to carry the hot air, the flames, and the burning brands directly forward. The predominant force of the south-west wind was sufficient to overcome any tendency towards local currents. But fluctuations in the direction of the wind always occur, and give rise to different statements as to its direction.* The draft of air upon the two sides of this rapidly progressing stream of fire, near the ground, was often very considerable. The lateral spread of the flames was against this draft, and of course was comparatively slow in its progress.

Masses of flame were blown forward, and are described as "balls of fire that were observed to fall like meteors in different parts of the town, igniting whatever they came in contact with." Another account says "that the fire came from the air above, more than from the earth. It swept along in detached clouds borne with a tornado-like fury. The clouds of fire would be swept along in waving masses of different sizes. A man describes one of these clouds as of forty feet in size each way. Whatever he saw it touch, the object, tree or house wilted directly down. These clouds of fire usually touched the tops of the tallest houses first, when the building would burn down as if saturated with kerosene. It seemed as if the air was charged with clouds of fire."

* But there can be no excuse for the blunder of an illustrated New York paper, by which the flames are represented as being carried in a direction exactly contrary to the fact.

The intense heat and great rapidity with which houses were consumed, are among the most wonderful facts connected with these fires, and have given occasion for the suggestion of several causes, both natural and supernatural. It is believed, however, that a slight consideration of the effects of the blow-pipe and of the blast-furnace will sufficiently explain all the observed facts. The strong wind, by constantly adding oxygen to the flames, increased their magnitude and the intensity of the heat.

The telegraph wires indicated no unusual disturbance of the electrical condition of the atmosphere, and the rapid production of flame, under the fierce blast of wind, will account for the intensity of the heat, without resorting to the absurdity of the decomposition of the atmospheric air.

We may therefore conclude that these fires were rendered possible, and owe their intensity and magnitude to meteorological causes, and that they neither confirm nor disprove Professor Espy's theory of storms and the artificial production of rain.

CONTRIBUTIONS TO THE SUBJECT OF BINOCULAR VISION.

By Prof. Chas. F. Himes, Ph. D.

(Concluded from page 413, Vol. LXIII.)

Refracting or Lenticular Stereoscope.

In many optical experiments either lenses or mirrors may be employed to produce a desired effect, and the question, which shall be employed, is decided by the peculiarities of the case. In the telescope, for example, a convex lens may be employed to furnish, according to the laws of refraction of light, an image of a celestial or other object, to be enlarged by the eye-piece or such an image may be presented to the eye-piece, by means of a concave mirror, by reflection. Each of these two large classes of refracting and reflecting telescopes has its advantages and disadvantages, and both have therefore been brought to a high state of perfection. It seems very natural, therefore, that it should have readily occurred to one so eminent and practical in optical science as Sir David Brewster, to bring about the deflection of light necessary to cause the apparent superposition of the pictures of a stereograph by refractors instead of by reflectors, as Professor Wheatstone had done, in the instrument just described. He doubtless was the first to substitute two prisms for the mirrors of the reflecting stereoscope, and

thus invented the refracting instrument now so generally employed in some one of its forms. The optical principles involved are of the most elementary character. Thus, according to the laws of refraction, a ray of light emanating from the point R′, fig. 11, of an object, on striking the prism at A will be bent toward the perpendicular to the surface of the prism at that point, and on emerging from the prism, at B, into the air, will be bent from the perpendicular at that point, so that its final direction will be BR, and the point from which it emanates will consequently be referred by the mind to the point C, in the direction from which the rays appear to proceed when they enter the eye at R. Another prism, with its edge toward that of the one given, looked through at the same time by the other eye, would place the image of a point in front of it upon the same point C. This is the simplest case of superposition by refraction, in actual construction of the stereoscope prisms with curved surfaces, or portions of lenses, are employed, which magnify as well as superpose the pictures. Thus, if an object, placed at the focal distance, say six inches, from a convex lens, be observed by a person looking through the centre of the lens, it will appear in its proper direction, but enlarged. If, however, whilst the eye remains in the same position, the lens be moved toward the right, so that the observer may look through the *left* edge of the lens, the image of the object will be found to move toward the left, or it will appear displaced, just as in case of the prism, fig. 11, and at the same time magnified. If the right eye is employed in this experiment, and another lens of the same focal distance is brought before the left eye, so that an object before it is seen through the *right* edge of it, the object will be displaced toward the right, and the lenses held in the hands may be easily adjusted by moving them nearer to or further from each other, so as to superpose the pictures of a stereograph, and obtain the usual stereoscopic effect. If the lenses are mounted on cardboard, or in wood, at the distance from each other ascertained by the experiment to be the best, an excellent stereoscope,

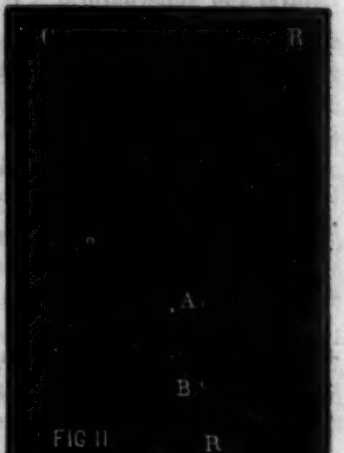


FIG II.

of most convenient form, will be produced. It will be better still, if an ordinary pair of iron-framed spectacles is cut apart at the nose-bridge, and the distance between the lenses so much increased, by inserting a piece of iron, that the eyes may look through the innermost edges instead of through the centres of the lenses. These stereoscopic spectacles may be worn like any others, and the stereograph may be moved back and forth, and from side to side, in front of them, until the best effect is obtained, which is very easily done, and they then leave little to be desired as a stereoscope.

The lenses are however usually cut in halves, and the halves transposed, or even quarters may be used, and thus each lens is made t afford one or more pairs of the lenticular prisms, as they may be called.

By looking further than the mere fact of apparent superposition of the pictures for the explanation of the aid afforded by the stereoscope, and the manner of the production of the stereoscopic effect, it will be readily seen that the action of the lenticular prisms, as of the mirrors in the previous instrument, renders unnecessary the dissociation of the habitual focal and axial adjustments of the eyes to the same point.

Thus, fig. 12, A B and A′B′ represent respectively the right- and left- eye pictures of the frustum of a cone, as shown in figs. 5 and 6, only moved a little further apart. If these pictures are united, without the aid of the stereoscope, by the method first described, in order to combine similar points, or that each eye may see points proper to itself, as B by the right eye, and B′ by the left eye, it is necessary for the optic axes to take the direction of the wide-spaced dotted lines, RB and LB′, or to converge, in this case, to a very distant point, which it has been explained, contrary to the opinions of Brewster, Rogers, Le Conte and Tyndall, might be at an infinite distance, or even a negative point.

Or it may be said that, in this case, the eyes must be rolled outward so far, that the light emanating from B may enter the right eye along its optic axis, and strike the point of distinct vision on its retina, and that from the point B′ enter the left eye under similar conditions. But, that vision of these points may be distinct, it is also necessary that the eyes should be respectively focally adjusted to them, or to the plane of the paper on which they lie.

A further consideration of fig. 12 will show how this convergence of the axes to a very distant point, and focal adjustment, at the same time, to a comparatively very near point, may be avoided by the use of the prisms. Suppose a lenticular prism be inserted before the right eye, R, and one before the left eye, L, with their thin edges inward. A ray of light from B, on striking the prism, will be refracted or bent toward the thicker part of it, toward the eye at R, omitting, to avoid complication of the figure, the expression of the fact that, at the second surface of the prism, in passing into the air, it would be still further refracted. The ray of light from B will, therefore, enter the eye from the direction of b, and, in order that the point B may be seen distinctly, this deflected ray from it must enter the eye along the optic axis, and strike the point of distinct vision on its retina; or, in other words, the optic axis must be directed towards b, the direction in which the light enters the eye.

In observing B, therefore, after the insertion of the prism, the eye is rolled inward until it takes the position in which it would be to look at b under ordinary circumstances. In like manner the left eye, in observing B′ through the prism, would be obliged to direct its axis to the point b. The eyes need not then be rolled outward to see their respective points, B and B′, since the prisms render this unnecessary by bending the rays of light coming from these points to suit the eyes, thus permitting the convergence of the optic axes to the point b, in the plane of the paper, to which the eyes are also focused. In the same way all the corresponding points of the larger circles will be apparently superposed, and form but one circle, a b.

But, if the refracting power of the prisms is adapted to the superposition of the larger circles, it is evident that the smaller circles will not be superposed; but since the similar points, as C and C′, of these circles are nearer together than the similar points of the larger circles, they will be carried, by the same degree of displacement as that which superposes the points of the larger circles, past each other, C would appear to be at c, and C′ at c′, or the smaller circles would

overlap, but not coincide. In order that c and c′ may coincide, the axis of the right eye must be directed to c, and that of the left eye to c′; the inclination of the axes to each other must therefore be rendered a little greater than that which they have when directed upon b; as the refracting power of the prism, which exactly superposes B and B′ in the case, is fixed, this change of inclination of the optic axes required must be, and is, readily effected by the eyes themselves, by a slight inward movement, until their axes cross at x, a point little nearer the eye than the plane of the paper. It is equally plain that in passing back to the observation of points of the larger circle again, the eyes must be rolled outward. It is this small residual work, necessarily left by the prisms for the eyes, this slight variation of the inclination of their axes, which the eyes themselves must make, in passing from the observation of nearer similar points of the pictures to the observation of more remote ones, and *vice versa*, that is similar in character to the work required of them in viewing the object itself, and which consequently produces the similar impression of relief.

By the employment of lenticular prisms, it is well to remember that enlargement of the pictures is effected, as well as their superposition; but the enlargement of the defects of the paper in part neutralizes this advantage, when paper views are employed.

Adjustments of a Complete Stereoscope.

The lenticular stereoscope, just described, is to be found in the market in a variety of forms, in many of which external appearance, perhaps a passing fancy, portability, cheapness, &c., have had as much influence in giving it shape, as adaptation to easy, satisfactory performance of its work. The instrument, indeed, is scarcely to be met with in as complete a form as was originally suggested by Sir David Brewster, and as it was placed upon the market in its earlier history. Much of the fatigue and general unsatisfactoriness frequently complained of in the use of the instrument, and consequent want of appreciation of it, as a means of instruction, study and research, as well as of recreation, may lie in the fact, that everything has not been done to relieve the eyes from any unusual effort, by rendering the instrument adjustable to the varying conditions under which it may be used, by different individuals, or with different pictures.

Adjustments to these varying conditions are not only essential to the completeness of the instrument, but they can be readily and cheaply introduced.

Since, then, the eyes of different individuals may differ greatly as to their focal length, or as to the distance at which they can see objects clearly, some being near-sighted, others far-sighted, no two perhaps being exactly alike in this respect, it is plain that there should be provision made for this variation in the instrument, that the distance between the picture and the portions of the lenses employed should be variable, either by an arrangement for moving the lenses to or from the pictures, or by moving the pictures nearer to or further from the lenses. The first plan was preferred by Brewster, and the lenticular prisms were placed in separate tubes, that could be slid back and forth, from or towards the pictures. In such cases the tubes holding the lenses must be prevented from turning, otherwise the position of the semi-lenses might even be so changed that their thin edges might be on the outside instead of the inside. The separate adjustment of these eye-glasses might be inconvenient in most cases, but in a few cases, where the two eyes of the same individual are not precisely of the same focal length, it might be advantageous. It is undoubtedly preferable, however, to have the lenses so arranged that they both move together. This focal adjustment is now more generally, and perhaps more conveniently, made, in most recent stereoscopes, by sliding the support, in which the stereograph is placed, back and forth before the lenses, so as to get the position of clearest definition. Indeed, it seems in this shape to have fought its way into recognition at the hands of the public, so that few instruments are to be met with in the market without it. It even seems strange that any should ever have been constructed without it; that in fact less care should apparently have been bestowed, in this respect, upon this instrument than upon most optical toys, especially when, upon reflection, it appears how richly attention to this point is repaid by the stereoscope. It is pre-eminently an instrument for the study of details; it is calculated to direct the attention to minutiæ that would, out of the instrument, be altogether unnoticed, to reveal features of the picture otherwise unsuspected, to cause apparently meaningless patches of shading or lines to assert their beauty and importance. How necessary, then, that full opportunity should be afforded to it by adjusting the pictures so that they can be clearly defined to the eye of any one.

There is another adjustment, however, which, if not absolutely necessary to the successful use of the instrument, is just as necessary to its completeness. It must be remembered that whilst the magnifying power of the lenses remains the same for all parts of the lenses, and

consequently, whether the object is viewed through the part d or e or f, fig. 12, that the refracting or deflecting power increases as the edge is approached, or that the section of a lens employed in the stereoscope acts, consequently, as a prism with varying angle. If the eye, therefore, looks through the lenticular prism at e instead of f, fig. 12, the right-eye picture will be thrown further to the left for that eye, and the left-eye picture further to the right for the left-eye, than when those eyes look through the points f, of their respective prisms. Or a person, whose eyes are nearer together than the average, and who would consequently look at the pictures through portions of the prisms nearer their edges, as e and e, or d and d, might have the rays of light so much deflected, that the pictures might be apparently moved past each other instead of being simply superposed; whilst in case of an individual, with eyes further apart, who would consequently look through the thick portion of the prisms, the pictures would not be moved far enough to be superposed. The amount of excess or deficiency of displacement of the pictures, from the above cause, might in many cases be very little, and the eyes, unconsciously, by a slight inward or outward movement, as the case might require, would remedy this instrumental defect and bring about the superposition, just as in fact they do in either of the methods given for combining the pictures without any instrument. They would, however, of course be doing more, or at least less natural and habitual, work than would be required of them if they looked through exactly the right points of the prisms, and therefore doubtless in many cases, from want of care in adjusting the distances of the lenses from each other to the average distance of the eyes from each other, and in others because the distance between the eyes of the individual exceeds or falls below the average, less satisfaction and more fatigue is experienced than should be.

A difficulty precisely similar to that just stated would be encountered if, whilst the lenses are perfectly adjusted to the eyes of the individual, so as to cause the pictures of a particular stereograph to combine readily without exertion, the stereograph were cut, and the pictures moved further apart, so as to require a greater degree of movement toward each other to superpose them, or if, which would amount to the same thing, a stereograph were inserted, the pictures of which were larger, and their similar points consequently further apart. Now, the size of the stereoscopic pictures in the market varies greatly, more than the distance between the eyes in different individuals; they may be

found from 2½ to 3¼ inches in width; the great majority however, are very near 2¾ inches.

These wider pictures, then, which consequently require more displacement by the lenses in order that their similar points may be superposed, might be readily combined, by an instrument which would allow the observer to look through portions of the lenses nearer the edges.

From the preceding remarks it will be apparent that, in order to use the stereoscope with the greatest degree of comfort, each individual should not only have one instrument adjusted to the distance between his eyes, but rather that he should have several, adjusted to the varying widths of the pictures, that will certainly be met with in any miscellaneous collection of stereographs. Several persons, in testing instruments carefully, may very easily and correctly pronounce different judgments upon their merits and demerits; for the distance between their eyes may not be the same, or they may, perchance, be examining pictures of different widths, and different instruments would, of course, suit these different conditions unequally well.

A very simple adjustment of the stereoscope will suggest itself to relieve both the difficulties mentioned—occasioned by varying interocular distance, or varying size of the pictures—and which would impart to the instrument a universal character, that is, render the same instrument equally adapted to all individuals, whatever the distance between their eyes, and all pictures, whatever their size, at least as found in the market, or even where their size considerably exceeds that of any found on sale, or is even as much as four inches in width. All that is required is a contrivance, by means of which the individual can readily select the portion of the lens through which to view the pictures, the thicker portions for the smaller pictures, and the more highly refracting thinner edges for the larger pictures. The instrument must simply permit of easy, uniform, simultaneous movement of the lenses from and toward each other, so that the eyes may always look through corresponding parts of their respective lenses, through f and f, e and e, or d and d, fig. 12, as may suit the case best. This adjustment is by no means a recent suggestion. The first forms of the instrument suggested by Brewster possessed it. He remarks:* "The two parts which hold the lenses, and which form the top of the box, are often made to slide in grooves, so as to suit different persons whose eyes are more or less distant. This adjustment may be made

* The Stereoscope, p. 66.

by various pieces of mechanism. The simplest of these is a jointed parallelogram, moved by a screw forming its longer diagonal, and working in nuts fixed on the top of the box, so as to separate the semi-lenses, which follow the movements of the obtuse angles of the parallelogram." He does not allude to the increased size of the pictures permitted by this arrangement, because the lenses are considered as fitted on to a box, as was invariably the case at first, and which he thinks has some decided advantages; but at another place, in describing a form of instrument as made by M. Duboscq, in which no box is employed, similar in this respect to the most recent instruments, he remarks: "By means of a screw-nut, shown above the eye-pieces, they can be adapted to eyes placed at different distances from one another. The advantage of this form, if it is an advantage, consists in allowing us to use larger pictures than can be admitted into the box stereoscope of the usual size."

The use of a right- and left-handed screw, working in nuts attached to the settings of the lenses, as proposed by Professor Emerson, gives a very easy, uniform and substantial method of adjustment.

Whilst this adjustment, as we have already stated, is not as absolutely necessary to the clearness of view of a stereograph as that of the focal distance, yet no one who has enjoyed the luxury of it in prolonged and careful use of an instrument so adjusted, will fail to understand how essential it is to the perfection of the instrument. The difficulty which many persons experience in "seeing the pictures single," will pleasurably vanish as the lenses are moved towards or from each other.

Besides, until pictures are brought into the market absolutely uniform in size, which cannot be hoped for even if desirable, such an adjustment will render pictures of all sizes equally satisfactory, even such as often, on account of their size, persistently refuse to combine; it would indeed render the latter more valuable on account of their larger contents. Special pictures, of larger size, $3\frac{1}{2}$ to 4 inches in width, might be made for such an instrument, and no one but an amateur photographer who, in study of a view learns to love its every petty detail, knows how much of beauty and excellence of his stereoscopic views, all before him in his print, must be cut off, sacrificed to the inexorable rule of $2\frac{7}{8}$ inches in width, or, at most, 3 inches, with the risk, in the latter case, of having an unruly picture for most of his friends. The allowance of a quarter of an inch more of width in a picture would frequently give a wealth of detail, or save some ob-

ject that would incalculably enhance the value and beauty of the picture.

With such an instrument in possession, the stereographs in the market can be purchased without fear of trouble; without it the most beautiful and comprehensive is apt to be the very one that is so large as to prove a source of disappointment and vexation, instead of pleasure.

Selection of a Stereoscope.

After the preceding statement of the essentials of a good stereoscope, a few hints in regard to the selection of an instrument will suggest themselves. External appearance, too, frequently controls the selection, instead of the manner in which the instrument accomplishes the work it is expected to do; but if much pleasure is to be expected, without unnecessary fatigue to the eyes, several points must be attended to.

Since the lenses, as a rule, in the instruments exposed for sale are not adjustable in a horizontal direction, and have consequently in case of each instrument a fixed deflecting power, it is well to see that their distance from each other is such that they will cause the pictures of the average-sized stereograph to unite readily for the person who is mainly to employ it, or for persons whose eyes are the average distance apart; otherwise the lenses, if too near, will not cause the pictures to overlap, or if too far apart will cause them to overlap too much—in either case the work left for the eyes to do has a tendency to cause fatigue. Of course the examination of a number of stereographs with the instrument will in a great measure be a test of its performance in this respect, but not as thorough a one as can or should be made, for the reason that the eyes of most individuals readily correct a slight deficiency in this respect, by accommodating themselves to the amount of deflection produced by the lenses, especially in the examination of an interesting picture, in which multitude of detail, perfection of perspective, shading, &c., invite them to do so. It is only by somewhat prolonged use of the instrument, therefore, that fatigue, resulting from this defect, renders it apparent, unless it is very great. Or again, the particular lot of stereographs examined may be beyond or within the average width of 2·75 inches, and the instrument not be adapted to the average stereographs. The exact size of pictures to which the instrument is best adapted may therefore most readily be ascertained by simply drawing two vertical lines, about ½ inch long, 2¾ inches from each other, on a card (the

back of a stereograph will answer), and placing it in the stereoscope, and observing how readily, or how nearly, the lines are superposed at first glance. If a series of such lines, different distances apart, are drawn on different cards, and placed in the instrument one after another, and looked at for an instant, the separation of the pictures for which that instrument is best adapted will soon be recognized. If any set of lines is steadily observed for some time, the eyes may unconsciously, by movement of the axes, cause the lines to be superposed, although the deflecting power of the lenses may not be best adapted to that purpose.

Again, in some instruments the lenses may be so mounted that corresponding portions of one picture may be thrown a little above those of the other picture. A trifling difference of vertical position is sufficient to prevent perfect combination, and to render the use of the instrument painful. An instrument with this defect should therefore be rejected. It can easily be detected by drawing on a card two sets of (three or four) horizontal lines, about ½ inch long, from ⅛ to ¼ inch apart, about 2¾ inches from each other, and noticing whether they coalesce when the card is placed in the stereoscope, or whether they form a double series of horizontal lines, caused by the lines of one of the sets being thrown slightly above instead of exactly upon the others.

Decided preference is given by Sir David Brewster to the form of stereoscope in which a box with a reflector, to throw the light on the pictures, is employed, as in almost all the earlier instruments on sale He remarks:* "The stereoscopic picture is injured by false reflections, and the sensibility of the eyes diminished. The exclusion of all light from the eyes, and of every other light from the picture but that which illuminates it, is essentially necessary to the perfection of stereoscopic vision." Whilst there may be some advantage in the use of the box stereoscope with glass views, the form without a box, as the Holmes' stereoscope, seems to be gaining in popular favor. A more agreeable illumination can certainly be obtained by it, by selection of a proper position with reference to the source of light, than by means of the reflectors attached to the box instruments, and even glass transparencies, with proper care, lose little of their effect in it, especially if viewed by artificial light. The stereoscopic spectacles before described can indeed be made to give about as good effect as any form of instrument.

* The Stereoscope, p. 71.

The large revolving stereoscopes, made to hold from fifty to several hundred views, although generally ornamental pieces of furniture, are somewhat clumsy and inconvenient as stereoscopes. They possess, however, several advantages not to be overlooked. They permit the arrangement of the pictures in series, or in such order as may be desired, for promiscuous examination, and thus prevent frequent and promiscuous handling, which so frequently proves fatal to glass views, and which, with the best of care, will to some extent soil and roughen paper views so as to mar their beauty, and obliterate the finer details. The injury from this cause may not be very apparent, except when the pictures are examined in the stereoscope. In some cases, too, by more careless handling, stains are developed by chemical action on the material of the photograph, which ultimately render it worthless.

No revolving stereoscope, however, can be of general satisfactory use, unless it has an arrangement which permits the adjustment of the lenses to varying focal distances of the eyes of different individuals. Most of them have such an adjustment.

In all the cases thus far considered, the employment of the ordinary lenses has been presumed. The use of achromatic lenses is frequently suggested, and instruments are made with them. In case of an instrument with horizontal adjustment of the lenses, such lenses would allow of further separation, consequently of the use of larger pictures, without the annoyance of colored fringes upon the pictures, but the ordinary stereoscopic lenses, with such an adjustment, will answer very well for views as high as four inches in width, and consequently all that may be met with in the market. Achromatic lenses might allow of pictures five inches in width. Since the ordinary lenses more than meet all usual cases, and the achromatic ones are only decidedly superior in extraordinary cases, and involve a decidedly higher price, achromatic lenses must be regarded as stereoscopic luxuries.

THE CHEMICAL THEORY OF THE VOLTAIC BATTERY.

By J. P. Cooke, Jr.

(Continued from Vol. LXIII, page 137.)

23. *Theoretical Interpretation.*—According to the theory advanced in these papers, the two kinds of electricity are simply different elements, or inconvertible conditions of the highly elastic medium which forms the molecular atmosphere. This etherial medium is supposed to be retained about the molecules just as the air is held to the surface of the earth, only the attractive force must be proportional to the

elasticity to be overcome. The elasticity of the ether, like that of the air, is due to its mechanical condition, and determines a similar state of permanent tension. The two parts of the ether correspond to the oxygen and nitrogen gases of the air, and the tendency to equilibrium is simply the result of a diffusive power similar to that which mixes together in unvarying proportions these elementary gases throughout the atmosphere of the earth, a power which, in the ether as well as in the air, may be referred to the mechanical conditions of the fluid. The diffusive power of the two conditions of the ether must be supposed, however, to be enormously great, as would naturally result from the wonderful elasticity and tenuity of the medium. When, therefore, two molecules come together, an instant mingling of their atmospheres results, and were there no external influences at work, the whole would be reduced to a uniform condition. But if, as is generally the case, the molecules are in a polarized state, induced by the influence of neighboring bodies, then there results such a redistribution of the two constituent electricities as these external causes may determine.

When, as described in the last section, we stroke the india rubber balloon with fur, the friction creates a disturbance in the molecular atmospheres, and, in some unknown way, determines an accumulation of resinous electricity on the india rubber, and of vitreous electricity on the fur. If now the two bodies are separated, the intervening air becomes polarized, and when both the balloon and the fur are insulated, we have at once the polar system represented in Fig. 13. Of this system the exterior surfaces of the balloon and of the fur are the two poles, and stand to each other in the same relation as do the two poles of a magnet. If, however, as is usually the case, the fur is not insulated, but held in the hand, then the charge of vitreous electricity does not necessarily remain on the fur, but distributes itself over neighboring conductors, so as to approach as near as possible to the balloon, shifting about as the balloon is moved, but following the india rubber ball everywhere, as closely as it can. What is true of the balloon is equally true of the sealing-wax baton or of the glass tube. *Every charge of electricity implies an equal and opposite charge on the surrounding conductors.* In all cases the electrified body is only one pole of a polar system, and is as necessarily associated with its opposite as is the north pole of a magnet with the south. If such, then, be the case, the phenomena of attraction and repulsion described in the last section are simply examples of the same reciprocal rela-

tions between like and unlike poles, which obtain in all manifestations of polar force.

The effect of the conducting power of the several electrics in modifying the phenomena we have been studying will be understood if we bear in mind that electrical conduction consists simply in the transfer of the etherial medium from molecule to molecule, and that this transfer takes place through different materials with very different degrees of facility. When we touch a metallic ball it is instantly discharged because the structure of the materials involved readily admits of the molecular motion by which the opposite electricities may be transferred from either side to the point of contact, and the exchange required to restore the equilibrium rapidly effected. On a mass of electrified resin or glass a similar motion would in time produce the same result, but the transfer takes place with great slowness, because, according to our theory, the structure of these bodies is such that the molecular motion, without which the transfer is impossible, is greatly impeded. By passing, however, the hand over the surface, we multiply the points of contact, and thus hasten the result.

24. *Electrometers.*—The effects of attraction and repulsion furnish a very delicate means of detecting and, under certain conditions, of measuring an electrical charge, and a class of instruments called electrometers are based on this principle. The simplest of these consists merely of two small pith balls, hanging side by side, and suspended from some conducting support by linen threads, also conductors of electricity. When attached to an electrified body the balls partake of the charge, and, being similarly electrified, repel each other.

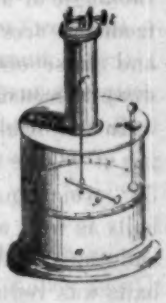
In the gold leaf electrometer two delicate strips of gold leaf take the place of the pith balls. To protect them from drafts of air they are covered by a glass bell, being suspended from a brass cap which closes the tubulature. The mouth of the bell is closed by a wooden base on which it rests. The base, as well as a large part of the interior of the bell, should be coated with tin-foil, in electrical connection with the earth, but carefully insulated from the brass cap.

The gold leaf electrometer is an exceedingly delicate instrument. When its cap is brought near or in contact with the body to be tested, the smallest electrical charge causes an immediate divergence of the strips. This instrument is also exceedingly well adapted for lecture illustrations. In order to render its indications visible to a large audience, it may be placed in front of the condenser of a magic lantern, and, with the aid of a lens, a greatly magnified image of the strips

thrown on a screen. The cap of the electrometer should be connected with the insulated metallic ball on the lecture-table, already described, by means of a wire coated with gutta percha or some equally effective insulation. The wire, if very long, of course diminishes the delicacy of the instrument, but it is still sufficiently sensitive for all ordinary experiments, and the divergence of the strips, when the receiving ball is electrified by contact or induction, produces a very impressive effect.

Neither of the two instruments just described measure, in any proper sense, the quantity of an electrical charge, and they are, therefore, properly speaking, not electrometers, but only electroscopes. The torsion electrometer of Coulomb, however, represented in Fig. 17, is capable of giving accurate measurements, and in the hands of Coulomb was of great service in the development of electrical science. It is simply an application of the well-known principles of the torsion balance to measuring the force of electrical attraction or repulsion, and is based on the well-known principle that the force of torsion, which here balances the electrical force, is always proportional to the angle of torsion.

Fig. 17.



The general structure of the apparatus is evident from the figure, and does not require description. The relative values of the force exerted between two electrified balls, under different conditions, is measured by the angle through which it is necessary to turn the point of suspension of a fine silver wire (f), in order to keep the balls at a given distance apart. The distance is measured on a graduated scale, and a second graduated arc around the point of support serves to measure the angle through which the wire has been twisted, or, in other words, the angle of torsion. One of the balls, made of aluminum and very light, is balanced at one end of a needle of "hard rubber," which serves to insulate it. The second body, also an aluminum ball, but larger than the other, is cemented to one end of a glass rod, whose upper end is inserted in a rubber handle. This handle fits an aperture in the glass cover of the instrument, through which the ball may be removed or inserted; and when the handle is in its place the centre of the ball is opposite the zero point of the lower scale. The principle of the torsion balance may be applied to electrical measurements in many ways; but the following experiments, to which the form of the instrument here

represented is well adapted, will illustrate not only the general method of using it, but also the fundamental law, according to which the strength of the electrical force varies.

Having removed the carrier ball, as it is called, we begin by adjusting the instrument, so that when the centre of the suspended ball is opposite the zero point of the lower scale, the index connected with the point of support shall also stand at the zero division of the upper scale. Turning now the needle slightly to one side, we electrify the carrier ball and replace it in position. It at once attracts the suspended ball, but, having imparted to this body a portion of its charge, the attraction is soon changed to repulsion. We now twist the suspension wire, by turning the upper circle until the two balls are brought within about 36° of each other; for calculation shows that if the angle of divergence does not exceed the limit, "the ratios deduced from the arcs (assumed to measure the distances between the balls) and those obtained from the rectilinear distances (which we cannot directly measure) do not differ by any sensible quantity."

In one of his experiments Coulomb found that, the upper index being at 0°, the angular deviation indicated by the scale (*c*) was exactly 36°, which may be regarded as measuring the distance between the balls as well as the angle of torsion. He then turned the circle (*e*), and thus twisted the suspending wire until the distance between the balls was reduced to one-half, or 18°, when he found that the upper index pointed at 126°, so that the angle of torsion was $126 + 18 = 144°$. Further, it appeared that, in order to reduce the distance to $8\frac{1}{2}$, it was necessary to twist the wire until, on the second revolution of the circle, the index pointed to 207°, making the angle of torsion $360 + 207 + 8\frac{1}{2} = 575\frac{1}{2}°$. We have then the following results:

Angle of Torsion.	Distances.	Squares of Distances.
36°	36	1296
144°	18	324
$575\frac{1}{2}°$	$8\frac{1}{2}$	$72\frac{1}{4}$

These numbers show that the angle of torsion, which measures the force of the electrical repulsion, increases in the same ratio that the square of the distance diminishes, the slight discrepancy in the last observation being within the limit of probable error.

Having thus proved that the repulsive force varies inversely as the square of the distance, we can next show what relation it sustains to the electrical charge, that is the excess of either electricity on the two balls of the electrometer. For this purpose we must untwist the

suspension wire, remove the carrier ball, and, having touched it with a second ball, the exact duplicate of itself, quickly return it to its place. On now repeating the same series of measurements as before, we shall find that when the distance apart is 36 the angle of torsion is 18°, that when the distance is 18 the angle is 72°, that when the distance is 9 the angle is 288°, and in each case one half of the previous value. Now, since we may assume that, under the conditions stated, the charge becomes equally divided between the two balls, so that only one-half remains on the carrier ball, it follows that the force measured by the angle of torsion varied directly as the quantity of the charge on this conductor. But it is evident that a similar result would follow any variation of the charge on the small suspended ball, which is assumed to have been in the same electrical condition during the whole series of measurements. The repulsive force, then, being proportional to the charge on each ball, its value must vary as the product of the two charges; and hence, if we represent the two charges by q and q^1, and the distance apart by d, we shall have for the value of the force

$$f = -\frac{q\,q^1}{d^2}$$

We can readily arrange the apparatus so as to give the balls opposite instead of similar charges, and measure the attractive instead of the repulsive forces. We find that the same law obtains in both cases, and the negative sign is used in the formula, since the force is positive or attractive when q and q^1 have opposite signs, and negative when they have the same signs. The theory of the instrument assumes that the charges on *m* and *n* are constant during the short time required for an experiment. This is not absolutely true, but if the air within is kept perfectly dry by means of a dish of calcic chloride, as represented in our figure, the loss of charge is exceedingly slow, and does not seriously effect the measurements. These experiments are interesting, and important as illustrating the method by which some of the most fundamental principles of electrical science were first established; but the electrometer of Coulomb has been superseded by more refined and delicate instruments, which will be hereafter described. We have revived it here because it is admirably adapted for lecture illustrations. By making the base and cover of plate glass, and painting the scales on the glass plates, the images of both balls and scales can be projected on the screen by means of the vertical lantern, Fig. 18, and the motion rendered visible to a large audience.

(To be continued.)

THE UTILIZATION OF THE LIGHT PETROLEUM OILS.

By William H. Wahl.

(A Paper read before the Optical Section of the Franklin Institute, March 28th, 1872.)

(Continued from Vol. LIV, page 432.)

The Chemistry of the Illuminating Process.—Before being able to decide the question as to the value, the danger, or the safety of any of the lighting agents designed for general use, it is necessary to possess a clear conception of the principles involved in the phenomenon of burning. The petroleum oils with which we are here interested furnish us with an example which we may regard as a type of the process wherever it occurs.

It must be understood that the materials used for illuminating purposes are changed to the condition of gases before performing their functions.*

The element to which we owe the light-giving property of all our household lighting agents, and which therefore enters largely into the composition of all of them, is carbon, the valuable constituent of coal.

In the burning of the hydro-carbon or petroleum oils the following process may be regarded as taking place:

The liquid material coming into contact with the flame, is broken up, mainly into two gases, called respectively the light and heavy carburetted hydrogens. The heat of the flame breaks up these gases into their elements—carbon and hydrogen; and it is in this condition that they burn, when in contact with the air. The hydrogen burns with the active constituent of the air—the oxygen—to form water. The burning of the hydrogen is attended with the evolution of great heat, but very little light, and hence of itself it is of no value as a light-giving agent. The other constituent of the petroleum—the carbon—does not combine so readily with the active principle of the air as does the hydrogen, their mutual affinities not being so energetic, and therefore this powerful neighbor succeeds in depriving a portion of the carbon of the oxygen with which to burn, until it reaches the outer boundary of the flame, and there meets with an abundant supply of air. To this apparently unimportant fact we owe entirely the *illuminating* quality of the flame. The carbon is separated from the carburetted hydrogens in the form of a most finely-divided solid body,

*The only exceptions to this rule are the cases of the electric and oxy-calcium lights, which depend upon an entirely different principle for their efficiency.

and these impalpably fine particles sailing into the intense heat of the burning hydrogen are heated till they become white-hot and brilliantly luminous. Upon reaching the outer margin of the flame these highly heated particles find an abundance of air, and are then burned up. If a cold piece of metal is held into such a flame for a few minutes, these particles of carbon are so far cooled down as to be unable to burn in the air, and are condensed upon the metallic surface as the black sooty deposit known to us as lampblack.

From the preceding it is clear that the proportions of carbon and hydrogen in a material used for illuminating purposes is a matter of great importance. The material may not contain enough carbon, and the result will be a flame intensely hot but dim; or, the material may, on the contrary, contain too much carbon, and the result will be not only a dim light but one which is also murky and smoking. The reason being that the flame is not hot enough, owing to its comparative poverty in hydrogen, to heat the floating carbon particles white hot, but heats them only to a red or yellow, so that on reaching the margin of the flame they are too cold to enable them to burn up, and they condense in the air as they did on the piece of metal in our experiment, and pass off unburned in the form of black smoke.

The quality, that is the light-giving power of a flame, is estimated by comparing its performance with that of some well-known standard which shall always give, as nearly as practicable, the same amount of light during a given time. This standard is, by general consent of scientific men, a candle of wax six to the pound. The instrument used for this purpose is called a photometer, or light measurer.

The question of the relative safety or danger of an illuminating agent is quite as important as that of its quality, and will likewise be briefly considered.

From what has preceded we need give no explanation for the assertion that the whole question of the safety or the danger of an illuminating agent depends upon the character of the material in a gaseous or vaporous condition. Where ordinary coal gas is used the danger resolves itself simply to a question as to the security of the pipes and stop-cocks through which it is supplied and consumed. It is simply necessary for an intelligent person to be assured that the fittings are perfectly tight, to remove all thought of danger from his mind. That there is an element of danger attending its use no such person will deny. Let us suppose that by some not at all improbable accident a pipe should become leaky, or that the case commonly im-

puted to our rural neighbors, should occur—that, namely, of extinguishing the flame without cutting off the flow. The result might readily end in a case of suffocation or conflagration, or both. Accidents with coal gas are, however, of comparatively rare occurrence, not that it is a harmless substance, but from the fact, which amounts practically to the same thing, that the elements of danger connected with its use, and the precautions to be observed, are so universally known that no intelligent person is ignorant of them. Though unacquainted with statistical information on the subject, we believe we will be perfectly warranted in the statement, that in the casualty lists of ten or twenty years ago, coal-gas did not play the comparatively unimportant role which it plays to-day.

Aside from coal-gas, the only other illuminating agents sufficiently introduced to warrant considering on the score of their safety, are petroleum and its products.

It is of the utmost importance that the public should be in possession of a full and explanatory statement of this question, if for no other reason, then for the fact of the present consumption in large quantities in the ordinary lamps of some of the light products of the rectifier, which are by legal enactment declared unsafe. These products, which are thus made the subjects, and properly, of legal restriction, are, unfortunately, not properly described when offered for sale, adulterating the heavier oils so largely used in portable lamps.

They are sold to be used in this way, either under the name of the heavier oils, which alone are suited for the purpose, or what is more generally the case, they are dubbed with any inviting or sensational name which shall conceal from the consumer their real nature.

It must not be understood that we mean to imply that these lighter petroleum oils are too dangerous to be used under any circumstances; the objection is simply urged against their consumption in the portable lamp, in which they cannot be used with safety, even in the hand of an intelligent and careful person.

The danger to which we refer resides in the great volatility of the lighter oils.

The very light rhigoline possesses this property in a most marked degree; a vessel of it left open at the ordinary temperature will very shortly be found empty. As we proceed to the heavier bodies, gasoline, naptha, &c., the volatility becomes regularly less as the gravity increases, until, when we reach the petroleum proper (88° and 60° B.), we find that they need a temperature of about 100° Fahr. to give off sufficient vapor to burn on the approach of a lighted body.

The danger attending the use in the ordinary lamp of oils having a comparatively low volatilizing temperature, will be evident from what follows. The heat of the flame is communicated to the neighboring metallic attachments, and from these to the body of the lamp, so that the oil within soon becomes sufficiently heated to fill with its inflammable vapor all of the space above the liquid.

Let the lamp, with this condition of things, be shattered by a fall, as not at all improbable. This vapor must be inflamed and ignite the oil, to the imminent peril of life and property. Or, let us suppose the equally probable case that a lamp in the condition described above is refilled while burning. The result might be, if possible, more disastrous than before; for the heated and inflammable vapor filling the upper portion of the vessel, would, by its rapid diffusion into the air immediately surrounding the light, quickly form an explosive mixture, by which the lamp might be broken and its burning contents scattered in all directions. When the oils to be burned in the portable lamp are of a heavier gravity, neither of these accidents could happen; since the heat communicated from the flame to the body of oil can never be sufficient (with a properly constructed lamp) to generate in the space above the oil a dangerous amount of vapor.

The mode by which the quality of the burning oils is tested, is called the "fire-test," and is simply the determination of the temperature at which the sample gives off an inflammable vapor, and of the point at which the oil itself begins to burn. An old law of Congress, regulating the sale of oil for portable lamps, fixed the first of these factors at 100° Fahr., and the second at 110° Fahr. It is a matter of regret that this excellent regulation is not more rigorously enforced, since nothing but the certainty of exposure and speedy punishment can avail to check the carelessness or, still worse, the cupidity of sellers; for it must be remembered that the demand for the lighter oils being limited, their price is lower than that of the petroleum proper. This fact offers a direct temptation for dishonest persons to adulterate their stock with oils of lighter gravity.

Of the extent to which this dangerous practice is carried, it is difficult, in the absence of reliable statistics, to form a correct judgment; but from the little information we do possess, there are good grounds for supposing that it is almost universal.

The report of the Fire Inspector of a neighboring city to the Board of Fire Underwriters, for the year just passed, contains the information that of sixty-three samples of oils purchased at different points

in the city, only eight of them, or 13 per cent., stood the fire-test, and could be burned with safety in the household lamp.

Now that the properties of the light petroleum oils have been presented, and the sources of danger attendant upon their use clearly indicated, it behooves us to consider the question as to whether these dangers can be met and obviated; in other words, to determine whether or not these valuable light-giving agents shall be altogether discarded for the purposes of household illumination, or whether any plans have been devised by which they can be utilized with a reasonable amount of security.

The defects of these products for use in the household lamp are precisely the difficulties which must be obviated. These consist, as has already been shown, of the difficulty of certainly confining the inflammable vapors, owing to the friable nature of the glass of which the body of these lamps are universally constructed, and the looseness of the joints; and again, the objection arising from the danger of careless refilling, where so many accidents occur. In many of the hundred odd gas machines which have been built within the last few years, these two objections have been obviated with more or less success—in some of them completely.

The first of these objections can be avoided by making the reservoir a fixture; a strong metallic box, the contents of which shall be hermetically sealed from contact with the air while being used; and, by locating this at some convenient distance from the dwelling, either above, or, better still, under ground.

The second objection, namely, the liability to accident in refilling, requires simply the obvious precautions that the operation shall be conducted in daylight, that the reservoir shall be large enough to contain a supply for several months, and that pipes or tubes and stop-cocks shall be called into requisition during the operation of filling.

With slight variation in detail, most of the automatic gas machines adopt these precautions, and, as a class, we have little hesitation in pronouncing them as safe as ordinary illuminants.

On the score of convenience, much depends upon the construction of the machine, the number of details of its operation, which require personal attention and which are automatic, and the complication or simplicity of its parts.

It need scarcely be said that, where ordinary coal-gas is at hand, these machines are unnecessary, most persons preferring the convenience of the former, without taking the question of economy into ac-

count. In places, however, where this is not to be had, and this happens to be the rule, these machines, with the above-named qualification, afford an admirable substitute for gas; for the advantage of enjoying in localities remote from cities the luxury of a light fully equal to the average of that afforded by coal-gas, more than repays the routine of attention which they demand. With an apparatus not cumbersome or complex, of which there are several to be obtained, the labor and attention to be bestowed upon it is but trifling.

On the score of economy, we believe that, with the exception of a few devices, employing certain gases (hydrogen, for instance), to take up the gasoline vapor, no person has raised a question; it being, so far as our knowledge extends, generally conceded, and correctly so, that in the simple forms of automatic machines, which simply carburet the air, the price of the illuminating product is less than that usually charged for coal-gas.

Having thus given the gas machine a general consideration, it will be advantageous to review briefly the different plans adopted by inventors in their construction; and while striving justly to avoid the imputation of invidious criticism upon anybody's machine, to point out the system which seems to meet the case most effectually and economically.

In a former portion of this review, it was stated that all the numerous plans for utilizing gasoline, were readily susceptible of classification into two groups.

In one of them a regulated current of hydrogen gas is generated in a suitable apparatus, by the action of sulphuric acid upon iron scrap; and the gas thus evolved is passed through the oil, or porous material moistened with it, and contained in a separate receptacle. The gas is in this manner charged mechanically with as much of the vapor of the oil as it can carry, and in this condition comes to the burner to be utilized. The light emitted is generally as good, or even somewhat superior, to the best coal-gas.

The process, however, is open to several and very serious objections; it is costly, and is altogether to ocomplex in its operation and in the parts of the machine to warrant more than a limited introduction.

This form of machine is unsatisfactory on the score of economy, though the beauty of the light obtained will go partly towards the amelioration of the grave item of expense, and perhaps the sale of the refuse matter in the generating vessel to the manufacturing chemist, for the extraction of the green vitriol, may effect a slight reduction.

The objection on the score of inconvenience resides in the introduction of details requiring frequent personal attention, and the incidental liability to become disordered if neglected. The reference here is to the generator, which must frequently be replenished; an operation which, from the nature of the acid and of the refuse, is a disagreeable one.

It is certainly to be regretted that a process which affords so excellent a light should be attended with objectionable features which seem to be unavoidable.

In the other group may be classed those machines in which the air is passed through the oil or porous material saturated with it, and the illuminating gas so formed utilized.

In some forms, heat is called to aid to assist the volatilization of the oil. In others, of simpler construction, the application of heat to the oil is omitted, and the air is simply passed through the reservoir at the ordinary temperature, though the volatilization is often aided by keeping the oil in constant agitation by various devices.

With the hydrogen as well as with the air-blowing machines there is considerable difficulty in securing a gas of uniform quality, owing to the fact that in cold weather the oil will volatilize with greater difficulty than when warm, and to the fact that the very process of volatilization is one in which heat is absorbed or rendered latent; so that several hours after a machine has been in operation, the oil within will be found to be sensibly colder than when started. The consequence of this difficulty is that the light will gradually loose in brilliancy, owing to the gradually diminishing amount of the oil vapor it carries with it. The earlier gas machines were from this cause nearly all worthless, and have either long since been abandoned or considerably modified to meet the objection.

In several existing forms of the air-blowing machine this difficulty has been so far obviated as to become of practically little consideration. The plan adopted in these is to keep the blower separate from the reservoir of oil, so as to operate upon very small quantities at a time; the constant influx of fresh oil from the tank thus preventing any serious diminution of the temperature during the operation. The supply is taken from the bottom of the reservoir and is automatically admitted in the necessary quantities by a ball and cock or other mechanical device. In addition to this the stationing of the tank under ground is likewise of itself a tolerably efficient means of keeping the temperature of the oil nearly constant at all seasons of the year.

There are some important details necessary for the proper operation of these machines, which it may be well to briefly mention.

It is evident the more thoroughly the oil is agitated and the longer it is kept in contact with the entering air, (hence the greater the amount of surface which the oil exposes to the air,) the greater will be the quantity of oil evaporated and the richer the gas. Hence, other things being equal, that machine which most effectually meets this requirement is the best. In the best machine of this class which we have seen, this was accomplished most effectually by a fan furnished with tilting buckets upon its edges, which, while it induced a current of air, at the same time keeps the oil in constant agitation. The fan strikes the oil in its revolution, the buckets lift the oil to the top of the box, and tilt it over a partition down a series of slightly inclined planes (supplied with bits of sponge) one beneath the other, by which it is obliged to traverse many times the length of the box before again reaching the well from which the buckets had removed it. The air on the other hand is made to travel over precisely the same course, but in an opposite direction; emerging at the top of the box, saturated and in condition to be supplied to the burners.

In certain machines, as before remarked, it is sought to aid the volatilization by heat, the air being blown into a vessel of oil, heated beneath by a flame; but, however effectual this process may be in maintaining regularity in the quality of the gas, it will never become a popular favorite, owing to the grave objection of the use of fire, by which the possibility of accident is greatly increased.

Taking all things into account, it would seem, then, that the simple air blowing machine, which does not involve the application of external heat, and which is constructed with reference to the simple conditions of safety and convenience which have been set forth in detail in several of the preceding pages, meets the requirements of practice better than any other, and should therefore be preferred by those desiring to introduce the gas machine in one of its many forms.

In conclusion, it may be remarked that the introduction of gas machines has greatly extended of late years, and, owing to the cheapness of the light petroleum oils, and the numerous improvements which have been made in construction, this increase bids fair to be still greater in the future. The whole subject is one of great practical interest, and it may safely be said that it has not received from the public that attention which its importance demands.

The reasons for this lack of interest and, in many cases, of positive